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DIGITAL VAX 11/80

DIAGNOSTIC SYSTEM
TECHNICAL DESCRIPTION

VAX11
780

BLANK

VAX-11/780 Diagnostic System Technical Description

First Edition, February 1979

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CHAPTER 1 INTRODUCTION

1.1 MANUAL SCOPE

This manual provides a comprehensive description of the functional and operational characteristics of the VAX-11/780 diagnostic system. The level of detail presented provides a resource for appropriate branch courses of the field service training program and for a field reference. Table 1-1 provides a list of related documents. Note that a glossary of diagnostic software terms is provided in Appendix A.

Table 1-1 VAX-11/780 System Manuals

Document Title	Control Number	Form
VAX-11/780 Power System Technical Description	EK-PS780-TD-001	In Microfiche Library
VAX-11/780 System Installation Manual	EK-SI780-IN-001	Available in hard copy*
DS780 Diagnostic System User's Guide	EK-DS780-UG-001	Available in hard copy*
DS780 Diagnostic System Technical Description	EK-DS780-TD-001	In Microfiche Library
FP780 Floating-point Processor Technical Description	EK-FP780-TD-001	In Microfiche Library
REP05/REP06 Subsystem Technical Description	EK-REP06-TD-001	In Microfiche Library
VAX-11 KA780 Central Processor Technical Description	EK-MS780-TD-001	In Microfiche Library
VAX-11 MS780 Memory System Technical Description	EK-MS780-TD-001	In Microfiche Library
DW780 Unibus Adapter Technical Description	EK-DW780-TD-001	In Microfiche Library
KC780 Console Interface Technical Description	EK-KC780-TD-001	In Microfiche Library
VAX-11/780 Architecture Handbook	EB07466	Available in hard copy*

Table 1-1 VAX-11/780 System Manuals (Cont)

Document Title	Control Number	Form
VAX-11/780 Software Handbook	EB08126	Available in hard copy*
VAX-11/780 Hardware Handbook	EB09987	Available in hard copy*
VAX/VMS Primer	AA-D030A-TE	Available in hard copy*
VAX/VMS Command Language User's Guide	AA-D023A-TE	Available in hard copy*
VAX-11 MACRO User's Guide	AA-D033A-TE	Available in hard copy*
VAX-11 Linker Reference Manual	AA-D019A-TE	Available in hard copy*
VAX-11 Symbolic Debugger Reference Manual	AA-D026A-TE	Available in hard copy*

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1.2 DIAGNOSTIC SYSTEM CAPABILITIES

The VAX-11/780 diagnostic system is a set of software components integrated as a system to provide a wide range of error detection and isolation capabilities for the VAX-11/780 hardware. The diagnostic levels range from system functional tests to dedicated microprogram techniques capable of identifying a faulty module (printed circuit board) or group of modules. In addition, the diagnostic control functions provide substantial selection and execution options.

The overall diagnostic strategy satisfies the major field service goals of:

- a. High quality and efficiency of system installation, by providing formal installation procedures, automated test package configurations, and a system exerciser program that can be configured for specific VAX-11/780 systems.
- b. Reduction of fault isolation and repair times, by providing high visibility diagnostic programs (programs accessible to the operator) and procedures keyed to the field service troubleshooting and repair philosophy.

The diagnostic system is supported by a PDP-11/V03 (LSI-11) microcomputer console system. In addition to providing for local (on-site) diagnostic execution, the diagnostic system allows for diagnosis from a remote diagnostic center.

1.3 DIAGNOSTIC SYSTEM OVERVIEW

The diagnostic system consists of programs that are organized hierarchically (from general to specific capabilities) in six levels. Each level contains one or more categories, as follows:

- Level 1 -- Operating system (VMS) based diagnostic programs (using queue I/O)
 - ^ System exerciser program
- Level 2 -- Diagnostic supervisor--based diagnostic programs that can be run either under VMS or in the standalone mode (using queue I/O)
 - ^ Bus interaction program
 - ^ Formatter and reliability level peripheral diagnostic programs
- Level 2R -- Diagnostic supervisor--based diagnostic programs that can be run only under VMS.
 - ^ Certain peripheral diagnostic programs
- Level 3 -- Diagnostic supervisor--based diagnostic programs that can be run in standalone mode only (using direct I/O)
 - ^ Functional level peripheral diagnostic programs
 - ^ Repair level peripheral diagnostic programs
 - ^ Cluster diagnostic programs
- Level 4 -- Standalone macrodiagnostic programs that run without the supervisor.
 - ^ Hardcore instruction test

Console

Level-- Console-based diagnostics that can be run in the standalone mode only

- ^ Microdiagnostics
- ^ Console program
- ^ Octal Debugging Technique (ODT)
- ^ ROM resident power-up tests
- ^ LSI-11 diagnostics

The diagnostic programs can be used for preventive maintenance checks to ensure proper computer operation; or, if system malfunctions have been detected, specific programs or groups of programs can be run to isolate the fault.

Figure 1-1 shows the relation of the six levels to four diagnostic program operating environments. The console environment requires exclusive use of the VAX-11/780 system (standalone mode). It includes only the console level programs. In this environment, program control is exercised by the LSI-11 processor in the console subsystem.

In the cluster environment, the system environment, and the user environment, control is exercised in the VAX-11/780 CPU. The cluster environment supports only standalone diagnostic programs. It includes level 4 programs and some level 3 programs. The level 3 programs supported are those that test the CPU and the channel adapters.

The system environment supports peripheral diagnostic programs that can run in the standalone mode. These include level 2 programs and level 3 peripheral programs.

The user environment supports only programs that can be run under VMS, namely levels 2R, 2, and 1.

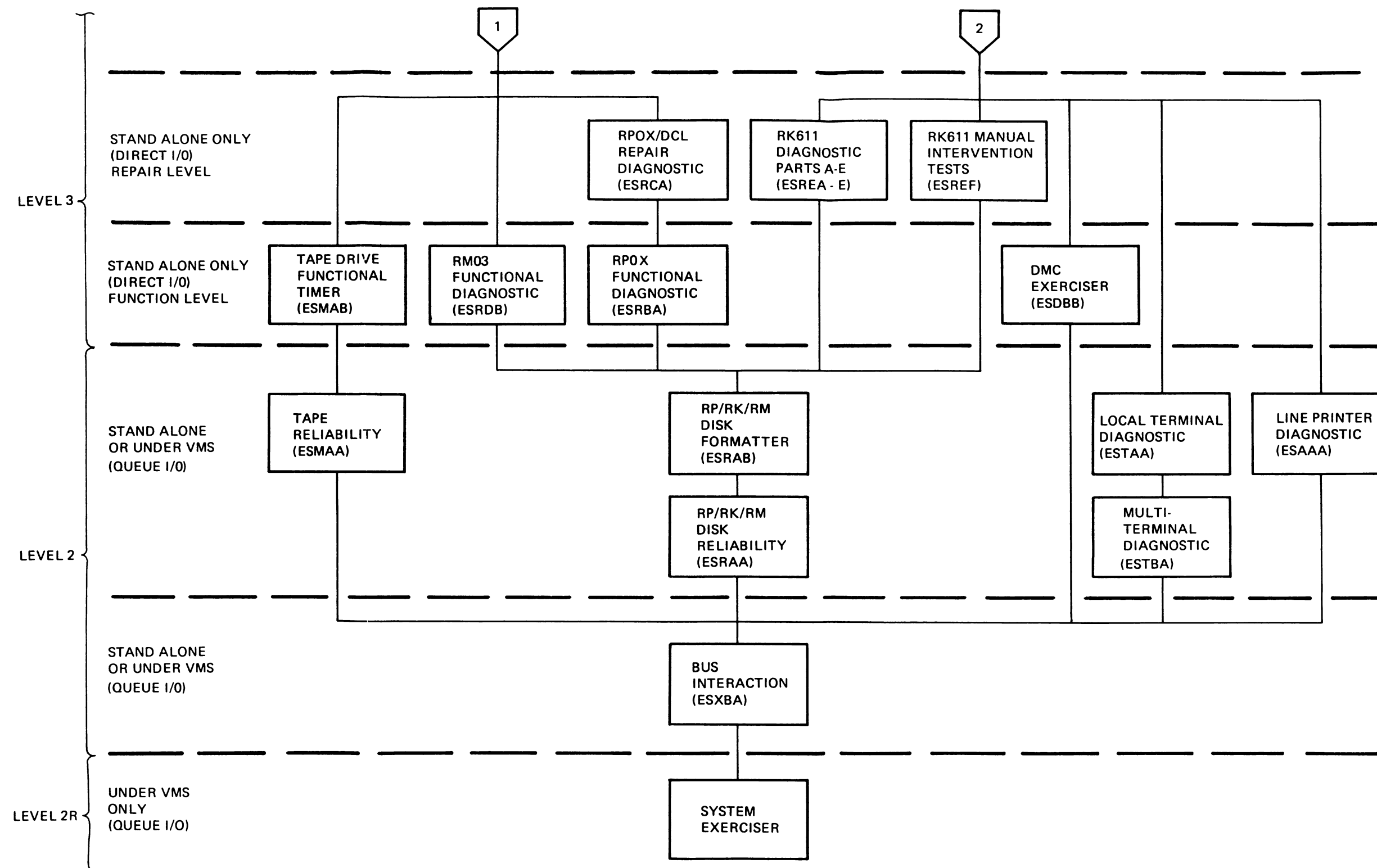
In general, the diagnostic system uses a building block approach to testing (and subsequent fault detection and isolation). When the diagnostic programs are executed in the standard system checkout sequence, they will initially test a minimum (basic) set of logical functions to ensure their proper operation. After these basic operations are verified, a larger and more complex block is tested, using the previously tested block as a base. This sequence is implemented consistently from the ROM resident power-up tests (which check the console) to interactive system tests executed as user mode tasks under the VMS operating system, as shown in Figure 1-2.

It may be that a diagnostic program will indicate an error in a hardware component which is more easily diagnosed by another program. For instance, the bus interaction program may indicate a failure of a tape drive. The tape reliability program may also detect the same failure or a related failure, but the problem may

MODE	PROGRAM ENVIRONMENT	PROGRAM LEVEL
OFF-LINE (STANDALONE)	CONSOLE ENVIRONMENT	CONSOLE LEVEL
	CLUSTER ENVIRONMENT	LEVEL 4
		LEVEL 3
	SYSTEM ENVIRONMENT	LEVEL 2
ON-LINE (UNDER VMS)	USER ENVIRONMENT	LEVEL 2R
		LEVEL 1

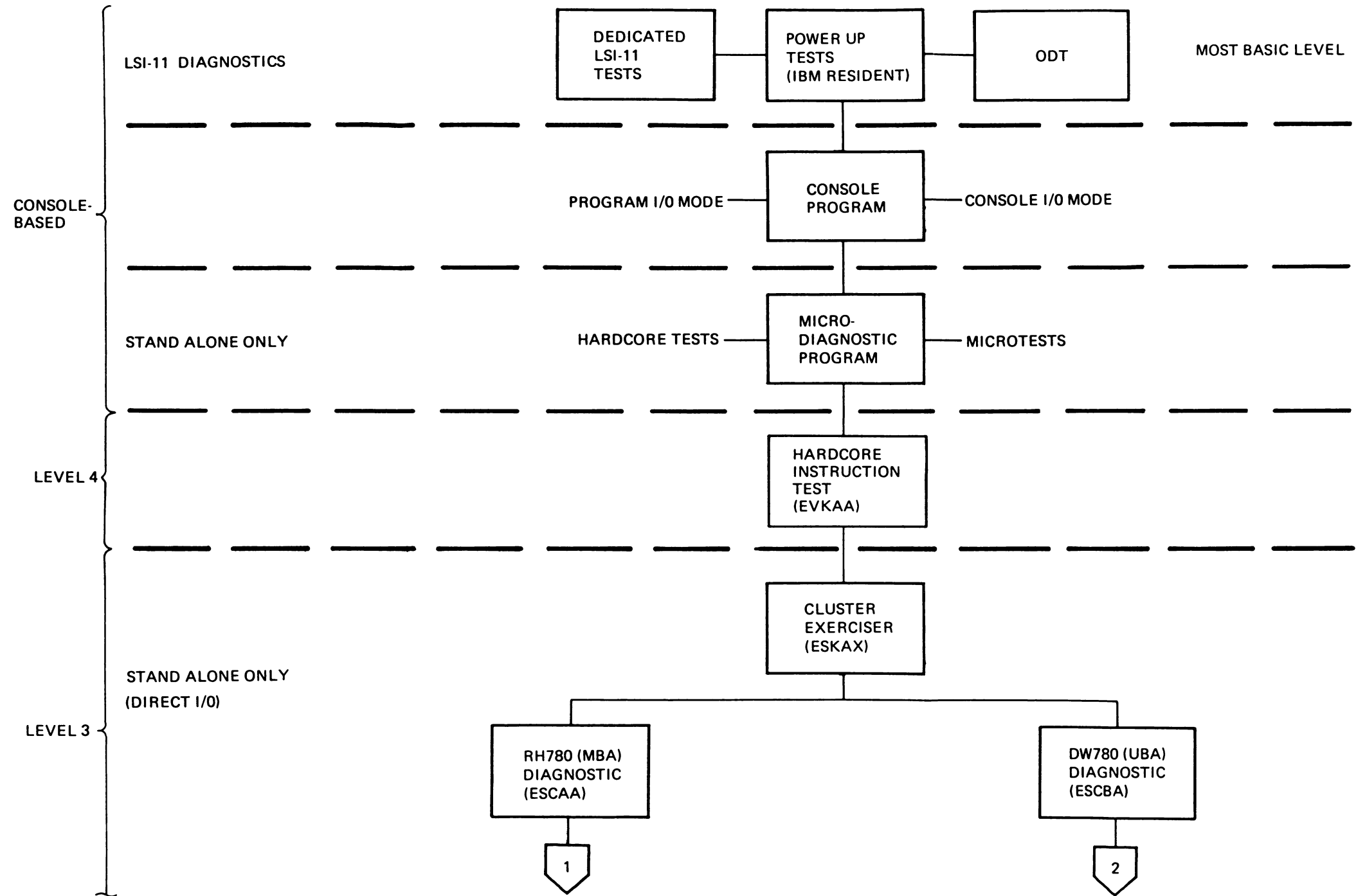
TK-1170

Figure 1-1 Diagnostic Program Mode, Environment and Levels



TK-0606

Figure 1-2 VAX-11/780
Diagnostic System Program
Hierarchy (Sheet 1 of 2)



TK-0607

Figure 1-2 VAX-11/780
Diagnostic System Program
Hierarchy (Sheet 2 of 2)

be on the tape drive controller, the RH780 (MBA), or the KA780 (CPU). Proper use of the six levels of diagnostic programs should enable the field service engineer to identify the failure quickly and accurately.

1.4 DIAGNOSTIC SYSTEM EXECUTION ENVIRONMENTS

Most of the diagnostic programs must be run off-line (standalone). In other words, they require exclusive use of the VAX-11/780 computer system and will not run under the VMS operating system. Diagnostic programs in levels 3, 4, and the console level are of this type (Figure 1-2). The diagnostic programs in level 2 can be run off-line or on-line (under VMS).

- ^ Off-line diagnostics must be run from the console terminal.
- ^ On-line diagnostics may be run from any terminal on the system and will share the computer system with other user mode programs. Figure 1-3 shows the execution environments required by the various diagnostic programs.

1.5 CONSOLE DIAGNOSTICS

On power up, a set of ROM resident tests verifies the proper functioning of the LSI-11 within the console subsystem before the console program is booted from the floppy disk. If the console program cannot be booted, the ROM resident tests, together with ODT, can be used to isolate the fault. For details see the VAX-11/780 Diagnostic System User's Guide (EK-DS780-UG-001), Appendix D. In addition, a set of dedicated LSI-11 diagnostics may be used to perform in-depth tests on each component of the console subsystem.

The console subsystem, in connection with the console program, provides the basis for the diagnostic system with the following functions:

- ^ Traditional lights and switch functions such as EXAMINE, DEPOSIT, HALT, START, and single instruction
- ^ Diagnostic and maintenance functions, including the capability to load diagnostic microcode into Writable Control Store (WCS), control execution, control single step clock functions, and examine key system points via a serial diagnostic visibility bus (V Bus), and to deposit and examine data in locations in the VAX-11/780 main memory and I/O space
- ^ Operator communication with the VAX-11/780 software.

The console program enables the operator to run microdiagnostics, to load and run the diagnostic supervisor (in the standalone mode) and the standalone macrodiagnostic programs (using VAX-11/780 native code), and to boot the operating system.

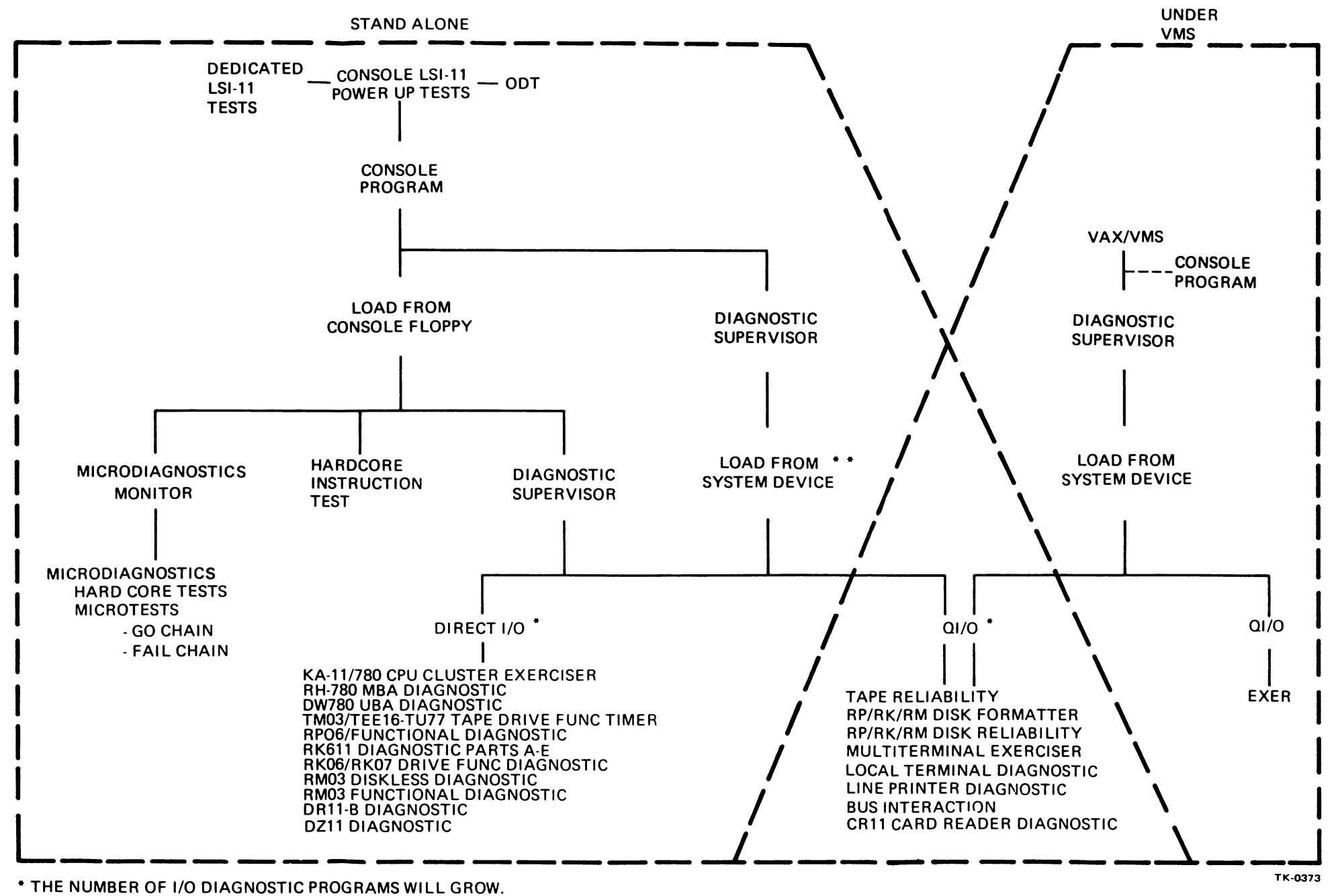


Figure 1-3 VAX-11/780
Diagnostic System,
Execution Environments

Note that when the console program is running in the LSI-11, it will always be in one of two modes, console I/O mode or program I/O mode. With the exception of the Control P (^P) command, the console commands (console command language) listed in the help files are available only when the console program is in the console I/O mode.

In the console I/O mode, the console program interprets the characters typed on the console terminal as console commands. In the program I/O mode, however, the console program is transparent to the operator. The console program passes characters from the console terminal directly to the VAX-11/780 CPU for use by VMS or the diagnostic supervisor.

Type Control P to switch from program I/O mode to console I/O mode.

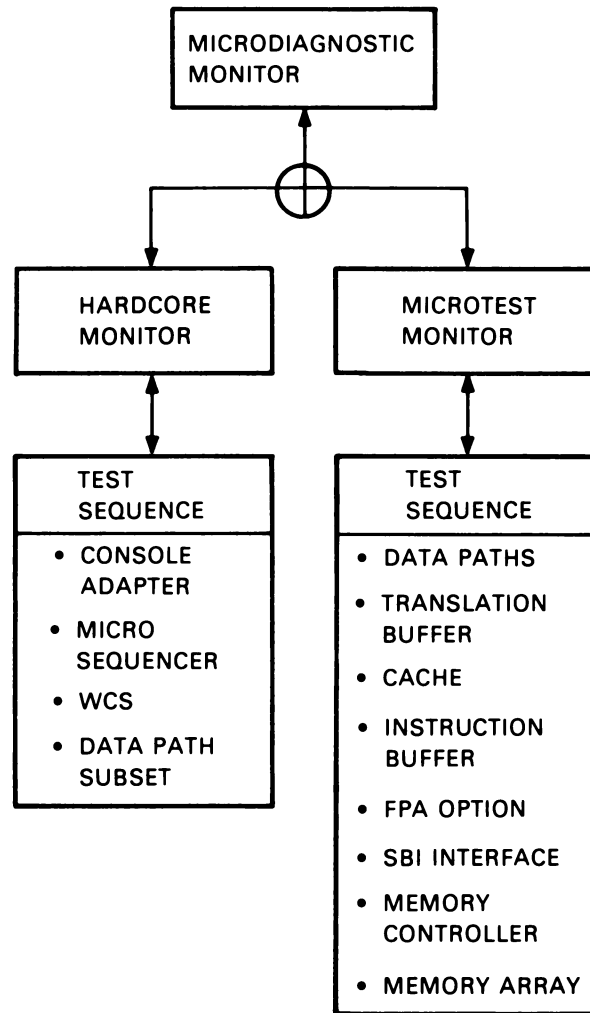
Type SET TERMINAL PROGRAM to switch from console I/O mode to program I/O mode.

1.6 MICRODIAGNOSTIC PROGRAM

The microdiagnostic program provides module isolation for logic failures within the CPU, floating-point accelerator and MOS memory controllers. The program will detect stuck high/low logic functions and open or grounded etch and wire interconnections. The microdiagnostics are organized in a bootstrapping test sequence (i.e., building blocks) of the console interface, CPU hardware, cache-translation buffer, I-stream buffer, Synchronous Backplane Interconnect (SBI), and memory controller and array. All detected faults result in an error timeout indicating the smallest set of modules to which the diagnostic can isolate the failure.

The microdiagnostic program is initiated by one console command and executed from the CPU cluster test facility. The test facility consists of the console subsystem, console interface, Writable Control Store (WCS), and the V Bus.

The microdiagnostic package consists of two major test divisions: console adapter and hardcore, and microtests. Each test division is controlled by an associated monitor that provides nondiagnostic services to that division. Both test division monitors are serviced by the console-resident microdiagnostic monitor. In addition to loading the test monitors, the microdiagnostic monitor retrieves microtest overlays from the floppy disk, loads test sequences into WCS, performs test dispatching and sequencing, performs error reporting, and manages fault isolation. The microdiagnostic monitor also allows the operator microdiagnostic test selection and execution options (Chapter 4). Figure 1-4 shows overall monitor relationships and test sequencing.



TK-0752

Figure 1-4 Monitor Relationships and Test Sequencing

1.6.1 Console Adapter and Hardcore Division

The adapter and hardcore division microdiagnostic is composed of a test stream of pseudo-instructions and test data located on the console floppy disk. Note that the pseudo-instructions are defined specifically for the test stream. This division tests the console adapter (CIB module), microsequencer, WCS, and a subset of the data paths. The hardcore monitor is called into the console memory by the microdiagnostic monitor. The hardcore monitor, in turn, retrieves small blocks (+1.5K bytes) of test data from the floppy into a console buffer, and then controls execution. When the current block has been completed, the hardcore monitor overlays this block with a new test block. The test data portion of the test stream is comprised of data words and lists of VAX-11/780 microinstructions. The microinstructions are loaded into the WCS and executed in single bus cycle or single time-state modes.

When an error is detected, an error header message is typed. Then, if the HALTD flag is not set, a trace message is typed and additional code is executed to isolate the fault. This additional testing will normally consist of V Bus compare instructions. Figure 1-5 shows monitor residency and the basic flow of the console adapter and hardcore tests.

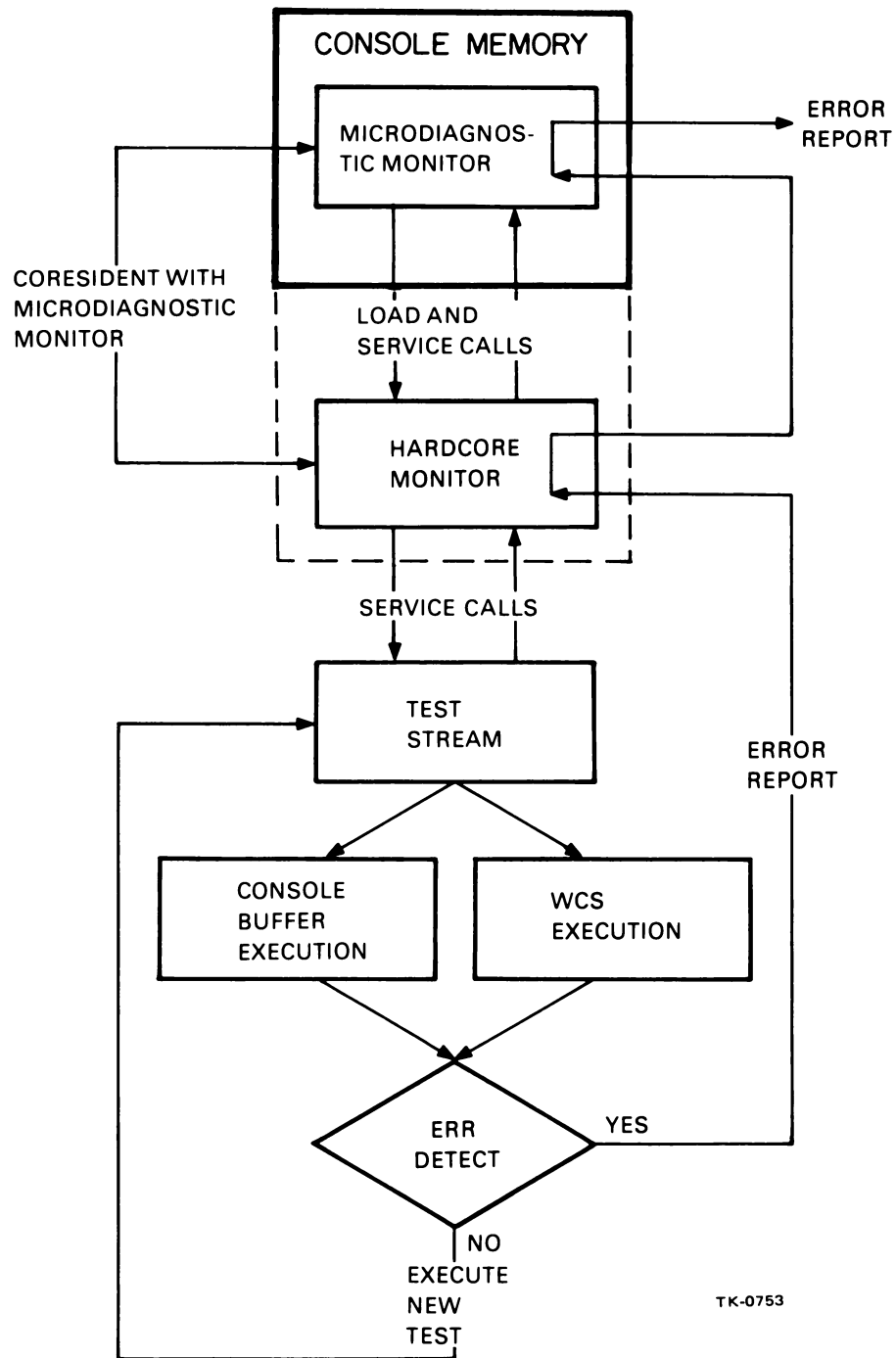
1.6.2 Microtest Division

The microtest division completes testing of the CPU not covered by the hardcore division, and provides isolation to a failing module. The microtests, which are executed under control of the microtest monitor, are divided into two subdivisions: GO chain and FAIL chain. The GO chain consists of microtests loaded into WCS and executed at full speed. The purpose of the GO chain is to detect an error. If an error is detected, control is passed to the FAIL chain, which isolates the error and reports the failing module through the microdiagnostic monitor. Note that the FAIL chain is executed only on detection of an error.

The GO chain consists of a series of WCS overlays. Each overlay is approximately 1K microwords in length and will contain one or more microtests. Initially, the microdiagnostic monitor loads the first overlay into WCS; that overlay is then executed. If no error is detected, the next overlay is loaded into WCS and executed. This sequence continues until each test in each overlay has been executed, or until an error is detected.

When the GO chain detects an error, execution of the microtest that detected the error is suspended. The error microtest address is saved and used by the FAIL chain to restart microtest execution to recreate the conditions that detected the error.

The FAIL chain reenters the failing microtest and begins fault isolation. The microtest is clocked a specific number of ticks from the error address and then certain V Bus signals are processed. If the V Bus signals identify the faulty module, an error report is made through the microdiagnostic monitor. If these



TK-0753

Figure 1-5 Hardcore Monitor Residency/Test Flow

signals do not identify the error, additional V Bus signals are processed. In the case of an intermittent error which is not reproduced during FAIL chain execution, a report is printed that lists the modules involved in the failing GO chain microtest. Figure 1-6 shows monitor residency and the basic test flow.

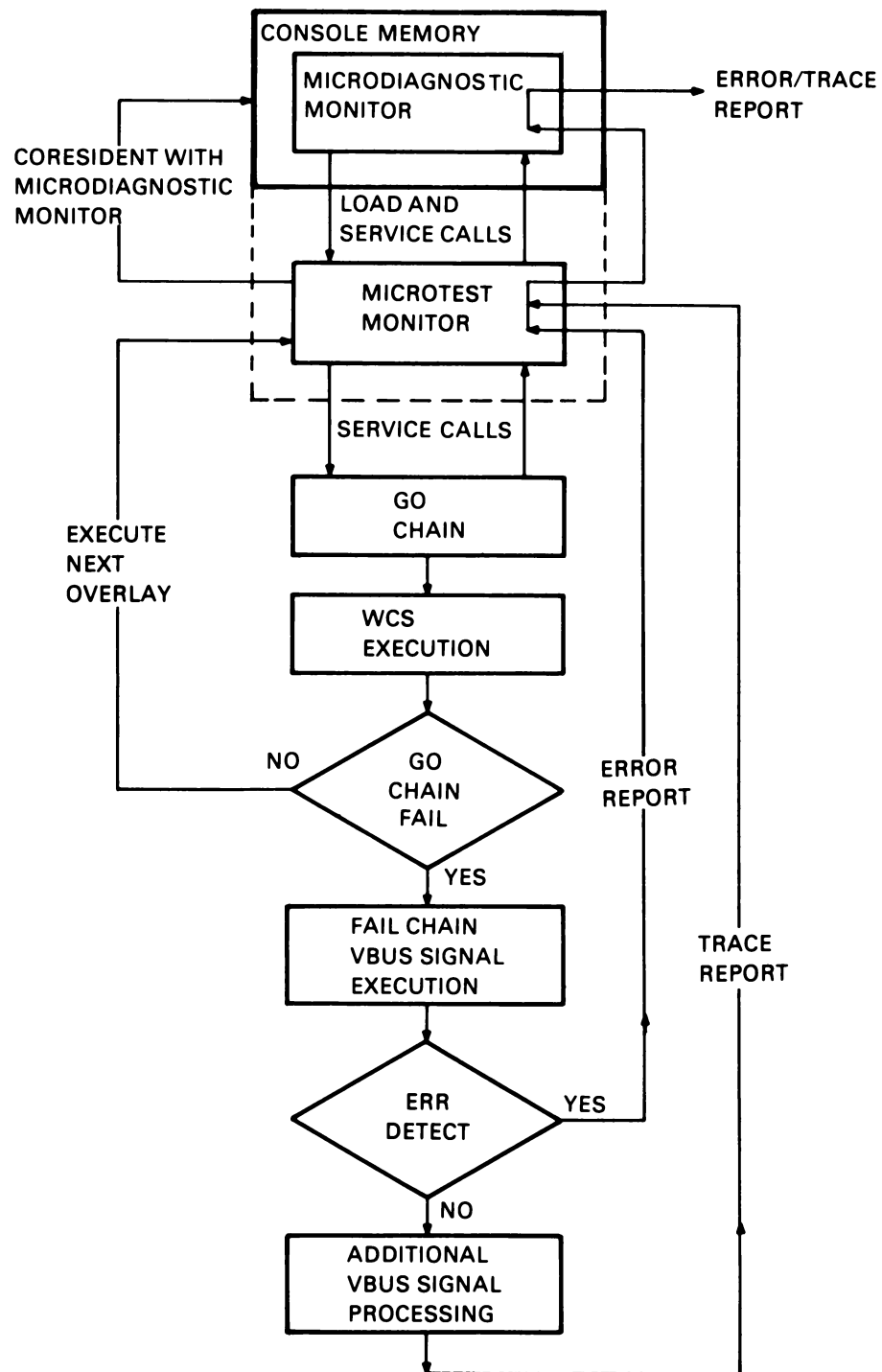
1.7 MACRODIAGNOSTIC PROGRAMS

The macrodiagnostic programs are written in VAX-11 MACRO and assembled in VAX-11 native code. Level 2, 2R, and 3 programs do not run independently; they must always be loaded and executed with the diagnostic supervisor.

1.7.1 Diagnostic Supervisor

The diagnostic supervisor provides a framework that supports each of the macrodiagnostic programs, one at a time. It operates in three environments and provides two major functions. Two of these environments, cluster environment (CE) and system environment (SE), constitute the standalone mode. The diagnostic supervisor operates in the user environment (USE) when it runs under the VMS operating system. In each of these environments different modules within the diagnostic supervisor are activated. The first major function of the diagnostic supervisor is the interpretation of the command line typed on the operator's terminal. The command line interpreter (CLI) portion of the supervisor performs this function, enabling the operator to control the loading, sequencing, and execution of diagnostic test programs. The program interface (PGI) performs the second major function of the supervisor, providing a set of common services required by some or all diagnostic programs. The PGI services include operator interaction routines, error message formatting, memory management, and I/O request handling. Notice that the operator can communicate with the diagnostic program only through the CLI and the PGI message service in the supervisor.

The supervisor supports programs that provide their own device interfaces (direct I/O) and programs that require I/O services. The direct I/O diagnostic programs must be run in the standalone mode (cluster environment and system environment), since VMS inhibits direct access to peripheral devices. Programs that do not directly access the peripheral devices under test rely on queue I/O system services. Both VMS and the diagnostic supervisor provide queue I/O system services, so that these programs can run in either the standalone mode (in the system environment) or the user mode (user environment, under VMS). When the diagnostic programs requiring queue I/O services are run in the user mode, the supervisor passes the queue I/O requests directly to VMS. When queue I/O diagnostic programs are run standalone, the supervisor emulates the VMS operating system, providing the queue I/O system services. Figure 1-7 shows the functions of the diagnostic supervisor in the three macrodiagnostic operating environments.

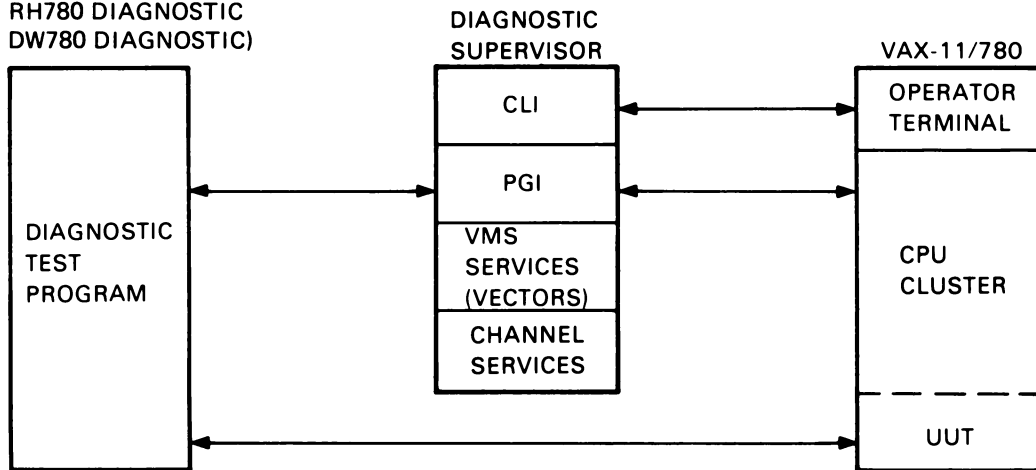


TK-0738

Figure 1-6 Microtest Monitor Residency/Test Flow

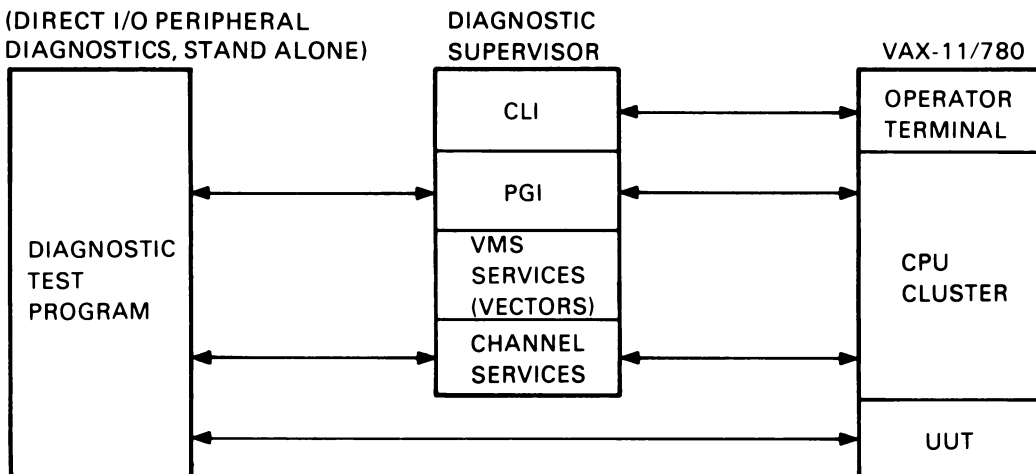
CLUSTER ENVIRONMENT

(CLUSTER EXERCISER
RH780 DIAGNOSTIC
DW780 DIAGNOSTIC)



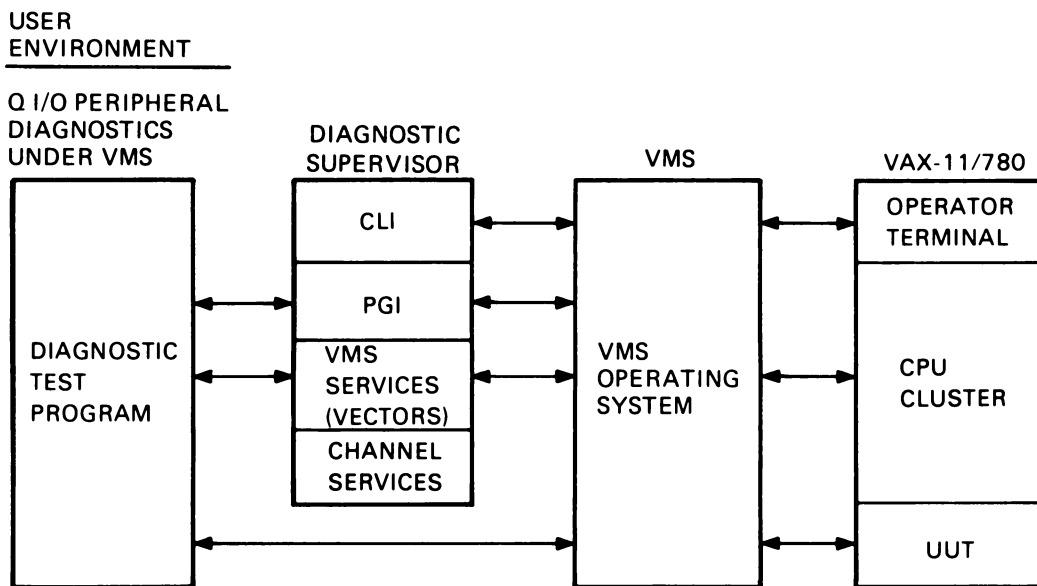
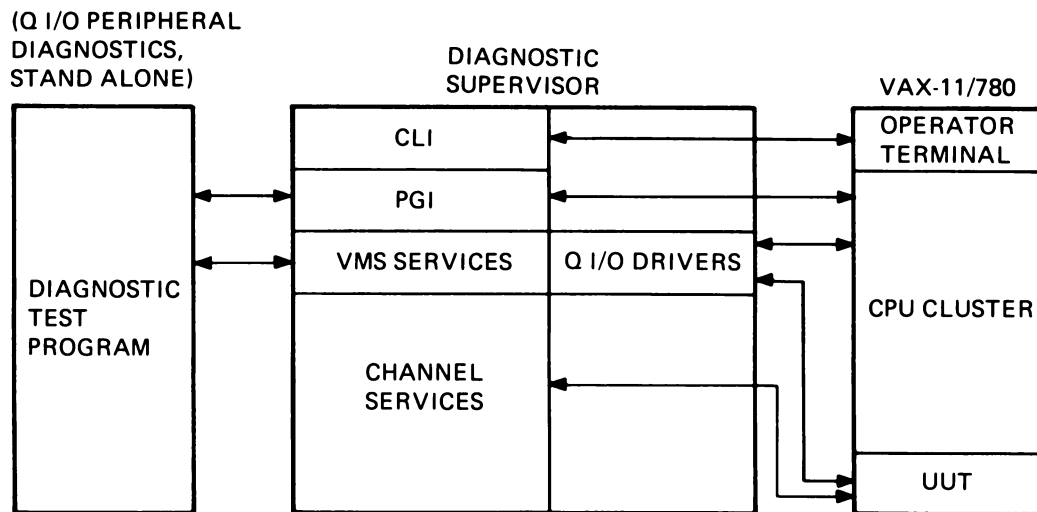
SYSTEM ENVIRONMENT

(DIRECT I/O PERIPHERAL
DIAGNOSTICS, STAND ALONE)



TK-0746A

Figure 1-7 Functions of the Diagnostic Supervisor Environments
(Sheet 1 of 2)



TK-0746B

Figure 1-7 Functions of the Diagnostic Supervisor Environments
(Sheet 2 of 2)

1.7.2 Cluster Diagnostic Programs

The CPU cluster exerciser, the RH780 (MBA) diagnostic program, and the DW780 (UBA) diagnostic program test the VAX-11/780 cluster hardware. They run under the cluster environment portion of the diagnostic supervisor, in the standalone mode.

1.7.2.1 CPU Cluster Exerciser Package -- The cluster exerciser package consists of three diagnostic programs. The package provides a comprehensive functional test of the CPU cluster, including the CPU, the Unibus and Massbus adapters, and memory. The first program (ESKAX) is the quick verify portion of the CPU cluster exerciser package. The second program (ESKAY) tests the native mode instruction set of the VAX-11/780. EXKAZ, the third program in the package, checks memory management and the PDP-11 instruction set (in compatibility mode).

The CPU cluster exerciser programs identify failing functions and failing subsystems. For further fault isolation the operator should run the microdiagnostic program or restrict the desired CPU cluster exerciser program to the minimum number of modules which will detect the failure, through commands to the diagnostic supervisor.

1.7.2.2 RH780 (MBA) Diagnostic Program -- The RH780 (MBA) diagnostic program tests the majority of the MBA logic regardless of the type of peripheral device attached to the Massbus. Although the program does not provide explicit component level fault isolation, every detectable error is associated with an operator-selectable scope loop. Diagnosis of attached devices is not attempted. Verification of the Massbus transceivers and cables is possible with a Massbus exerciser (MBE, RH11-TB) attached to the Massbus. Use of an MBE on the Massbus also allows verification of the MBA ability to perform high speed block transfers. Note that either a device or a bus terminator must be attached to the Massbus to enable program execution. The program tests the MBA at three levels.

1. The first level checks basic functions. The functions tested are those which are necessary for subsequent, detailed fault detection. The objective is to locate functional failures prior to testing for explicit bit failures. Map register access, virtual address register access, and correct data input buffer byte selection are tested at this level.
2. The second level of testing locates bit failures (stuck high/low). The program toggles bits directly accessible to the CPU, and it sets and clears bits indirectly by setting up specific commands and conditions.

3. The third level determines the ability of the MBA to meet system demands. The program performs block transfers using the MBA wraparound features. These block transfers are executed in the maintenance mode and ensure that the MBA will support data transfers typically associated with system software. In addition, the program tests the ability of the MBA to interrupt the CPU under all legal conditions.

1.7.2.3 DW780 (UBA) Diagnostic Program -- Like the RH780 (MBA) diagnostic program, the DW780 (UBA) diagnostic program tests most of the UBA logic. Every detectable error is associated with an operator-selectable scope loop. The program does not attempt to test devices attached to the Unibus. However, if a Unibus exerciser is attached to the Unibus, the program will verify the integrity of the Unibus transceivers and the ability of the UBA to respond to device-initiated functions. The program tests the UBA at seven levels.

1. The program tests the basic functions necessary for subsequent fault detection: the addressability of the UBA registers, their initial states, and whether they can be read and written.
2. The program tests the RAM addressing capability of the UBA logic (accessing map registers, data path registers, and BRSVRs).
3. Power-fail and interrupt functions of the UBA are tested next.
4. The program creates and tests all error conditions.
5. Extensive data transfer tests check the map registers, the direct data path, the buffered data paths, the data path registers, the Unibus address and data lines, and the microsequencer.
6. The device tests check all types of data transfer on the Unibus: DATI, DATIP, DATO, DATOB initiated by the UBA and by the UBE. Interrupts from the UBE to the CPU are also tested at the four BR levels.
7. The contention logic test checks for race conditions when the four microsequencer select lines (UBATT SEL, SB SEL, DMA SEL, FILE WRITE SEL) are asserted at about the same time.

1.8 PERIPHERAL DIAGNOSTIC PROGRAMS

In accordance with the structure of the diagnostic system as a whole, the peripheral diagnostic programs are organized in a hierarchy. Repair and functional level programs are designed to test specific peripheral devices. These programs (with the exception of the line printer and terminal diagnostics) must be executed in the standalone mode under the system environment (SE) services of the supervisor, since they provide their own access (direct I/O) to the devices under test. The diagnostic programs which rely on VMS, or the supervisor, for access to the units under test (queue I/O) are each designed to test a range of peripheral device types. For example, the disk reliability program (ESRAA) will test all disk drive types supported by the VMS operating system.

On error detection, the repair level diagnostic programs will call out both the failing device controller module and the failing function, dump the contents of relevant registers, and list expected and received data patterns. The functional level programs provide register dumps and call out the failing function when an error is detected. The reliability and formatter level programs provide more detailed information on the failing function in addition to the register dumps.

The system exerciser program tests the integrity of the major system buses (i.e., SBI, Massbus, Unibus) under heavy I/O activity, and it highlights any interaction problems that result. The program should be run as a dedicated process under VMS. No other program may run concurrently or compete for system resources, since the program requires the use of all system resources.

1.9 OPERATOR/VAX-11/780 COMMUNICATION

The operator communicates with the VAX-11/780 computer through the console subsystem. The console subsystem provides a programmed interface between the console terminal and the VAX-11/780 hardware and software, including the diagnostic system. The console subsystem hardware consists of an LSI-11 microprocessor (11/03), a single floppy disk drive and controller, a terminal and two serial line units, a VAX-11/780 CPU console interface (CIB), and a control panel on the VAX-11/780 CPU cabinet. The console program includes a console command language and the software utilities that provide operator console functions. These functions are required for VMS and diagnostic support. The paragraphs that follow introduce the basic console functions. Refer to Chapter 2 for a detailed description of the console command language.

1.9.1 Console Terminal Modes

The console terminal serves as the console program's I/O device and as a VMS operator terminal. The console program has two operating modes: console I/O mode and program I/O mode.

In console I/O mode, the terminal serves as the operator interface to the console panel functions, CPU debug functions, and CPU kernel test functions. In this mode console terminal input is not

passed to the VAX ISP-level software. All terminal input is interpreted by the LSI-11, and appropriate console functions are invoked.

In program I/O mode the terminal serves as a VMS operator terminal. All terminal input is passed, character by character, to the ISP-level software. All validity checking, etc. is performed by VMS. The console program is transparent to the VAX-11/780 software. All terminal output from the software is passed directly to the console terminal.

1.9.2 Console Panel Equivalent Functions

The functions in this group are those normally available through a traditional console panel. These functions include ISP-level program and CPU clock controls, and display and modification of memory elements.

1.9.2.1 Program Control -- The console can initialize the CPU by setting certain logic to a defined state. It can initiate ISP-level instruction execution at a point specified by the program counter, as well as terminate instruction execution. In addition, the console can bootstrap the system by loading memory with a specific file from the system load device, and initiate instruction execution at a predefined address after the load. The console can also stop ISP level instruction execution.

1.9.2.2 Memory Element Display and Modification -- The console allows display and modification of memory elements in the VAX-11/780 including main memory, I/O, general, and internal register addressing space. The address spaces can be accessed, read, and written in the quantities specified below:

- a. Main memory elements: byte, word, longword, quadword quantities
- b. CPU general registers (R0--R13, SP, PC), and processor register space: longword quantity
- c. CPU processor register space: longword quantity
- d. I/O registers: byte, word, longword quantities depending on register data length
- e. ID bus registers: longword quantity
- f. VAX-11/780 V Bus (Visibility Bus) channels can be displayed (V Bus channels are read-only)
- g. VAX-11/780 main memory and/or Writable Control Store (WCS) can be loaded from files on the console subsystem floppy disk.

1.9.2.3 Clock Control -- The CPU clock can be controlled by the console to provide single step clock mode for use in hardware or software debugging. The control modes available include single instruction step, single SBI bus cycle step, and single SBI time state step modes.

Single instruction step mode allows ISP-level programs to execute one instruction at a time. This mode causes the CPU to enter the halt state after the instruction execution.

Single SBI bus cycle step mode causes the CPU clock to stop each time SBI time state 0 (T0) is asserted. T0 remains asserted until a control signal from the console causes the clock to resume operation. The clock ticks until the next SBI T0.

Single SBI time state step mode causes the CPU clock to assert and hold a time state (T0, T1, T2, or T3) until a control signal from the console causes the next time state to be asserted and held.

1.9.3 Console Control Functions

The console control functions allow control of numeric radices, addressing modes, and data length, and provide for displaying console and CPU status. Functions are also provided that repeat commands and link multiple commands into a single executable command list. In addition, the console provides a means to control the number of fill characters to be added after special characters are sent to the console terminal.

1.9.3.1 Default Settings -- The console allows specification of defaults for addressing modes, radix of numeric input and output, and the data length of addressable memory elements. Any default setting can be overridden within the context of a console command.

- a. The default addressing modes can be set for virtual, physical, ID Bus, V Bus, general register, or internal (processor) register.
- b. Default radices for console numeric input and output can be set to octal, decimal, or hexadecimal radix.
- c. Defaults for memory element data lengths can be set for byte, word, longword, and quadword.
- d. Power-up defaults --

Address Type	=	Physical
Radix	=	Hexadecimal
Data Length	=	Longword (32 Bits)

1.9.3.2 Status Displays -- The console provides a means to display CPU and console subsystem status. The CPU status includes the stop/run state of the instruction set processor, the current clock step mode, and the state of the Stop on Microbreak Match Enable (SOMM). Console subsystem status includes the current setting of all console defaults and the number of terminal fill characters.

1.9.3.3 Command Linking and Repeating -- The console provides a facility that allows multiple commands to be linked into a single executable list. Commands to be linked are entered into an internal console queue. The console operator can specify execution of the command queue one pass at a time. Or, the queue may be executed continuously. This facility allows the diagnostic user to create short routines of console commands for use in hardware debugging operations.

The console also provides a facility to continuously execute a single command or list of commands. Once initiated, command execution continues until terminated by the operator. The repeat facility allows maintenance personnel to scope the operation of CPU and subsystem logic invoked by console commands.

1.9.3.4 Real-Time Delays -- The console provides a facility for introducing real-time delays of varying duration between the execution of console commands linked with the command linking facility. This function has no effect on the CPU, but only delays the console's processing of the next sequential command in the command queue. The delay facility is provided for use after console commands that invoke CPU functions which require time to complete (e.g., initialization).

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CHAPTER 2 CONSOLE PROGRAM AND CONTROL DESCRIPTION

This chapter describes the console command language and associated command facilities. Where appropriate, examples of command usage are included. Also included are all applicable console error messages.

2.1 CONSOLE PROGRAM OVERVIEW

The following paragraphs provide a basic overview of the console software modules. Note that the services provided by the console are contained in the LSI-11 4K ROM and 8K RAM. The console provides services for console control, operator interface, microdiagnostic execution, VMS support functions and remote diagnosis.

2.1.1 Command Getter

The basic functions of this module are to retrieve a command line from the console terminal (get a command line routine), and provide a check point (or wait) loop for the console program (console null loop).

The program spends the majority of its time in the null loop, which consists of a series of test points and conditional branches (e.g., bootstrap initiated, VAX-11/780 CPU halted, etc.). Should any of these functions be active (i.e., flag set) the program performs a branch to the routine required to service the request initiated by that flag.

2.1.2 Parser and Parser Tables

The parser module decodes the command typed on the console terminal and provides a pointer to the appropriate routine to execute the command. The parser manipulates the command line to condition it for decoding (e.g., discarding leading blanks and checking for a delimiter in the command input string). The command is decoded through a set of syntax check trees that provide pointers to the appropriate execution routine within the command execution module. Any data required for command execution has been set up in tables included as part of the parser.

2.1.3 Command Executor Module

The command execution pointer from the parser is passed to the command execution module entry point. This entry point provides a pointer (i.e., starting address) to the appropriate command execution routine (e.g., DO BOOT, PERFORM QUAD CLEAR). The basic sequence of module action is:

- a. Apply switches or defaults for radix, address space, and data length.
- b. Execute command routine.
- c. Test for repeat function.

If a repeat function is specified, the routine monitors the console for the control character (^C) required to terminate the loop.

The module also supplies the required subroutines to support the execution functions (e.g., open a file, load a file). Following command execution, control is passed to the console null loop within the command getter module.

2.1.4 Additional Services

In addition to the command decoding and execution functions, the console provides several other services.

Remote support is provided to allow console access from a remote terminal or computer. The facility also enables communication between local and remote operators, as well as transfer of console control between local and remote operators.

VMS services are also provided. These services include routines for terminal support and the associated drivers, as well as a file service for the floppy drive and its associated drivers. The code for some of these services is contained in the ROM as well as the RAM. These services are provided through emulator traps.

The console software also includes the basic LSI-11 processor and memory tests, that are executed on each power-up and bootstrap, and the primary bootstrap routine for the floppy.

2.2 COMMAND TERMS AND SYMBOLS

Table 2-1 provides a summary of terms and symbols used to describe the syntax of the console commands.

Table 2-1 Term and Symbol Definitions

Term/Symbol	Definition
< >	Used to denote a category name (label) e.g., category name <address> represents a valid address
!	Used to indicate the Exclusive OR operation (i.e., selection of parameters within a command line). For example, <A>! means either <A> or but not both is to be selected
()	Used to indicate that one of the syntactic units of the expression is to be selected
[]	Used to indicate the part of an expression that is optional e.g., WAIT [] indicates that the wait command takes an optional count argument

Table 2-1 Term and Symbol Definitions (Cont)

Term/Symbol	Definition
<blank>	Represents one or more spaces or tabs
<count>	Represents a numeric count
<XYZ -list>	Indicates one or more occurrences from the category indicated by XYZ
<address>	Represents an address argument
<data>	Represents a numeric argument
<qualifier>	Represents a command modifier (switch)
<input prompt>	Represents the console's input prompt string '>>>'
<reverse prompt>	Represents the linking prompt '<<<'
<CR>	Represents a console terminal carriage return
<LF>	Represents a console terminal line feed
/	Delimits a command from its qualifiers
+	Represents the default address when used as an address argument in an examine or deposit command (The default address is the last address used plus the current data length in bytes.)
*	Used as an address argument in an examine or deposit command and represents the last address referenced.

2.2.1 Notation Examples

EXAMINE [<qualifier - list>] [<blank> <address>]

An examine command explanation follows.

- a. An examine command may optionally contain a list of one or more qualifiers.
- b. An examine command may optionally contain an address argument. If the address is specified it must be preceded by one or more spaces or tabs.

Following is a list of valid examine commands:

```
EXAMINE
EXAMINE/BYTE/VIRTUAL
EXAMINE <space> 123456
EXAMINE <tab> 123456
EXAMINE/WORD <space> 123456
EXAMINE/WORD <space> <tab> 123456
```

2.2.2 Command Abbreviations

Console command words may be abbreviated by typing only enough characters to identify each command word. The minimum abbreviation for each command is specified in parentheses in each command description paragraph title.

Example

```
EXAMINE/VIRTUAL/BYTE 1234
```

may be abbreviated to:

```
E/V/B 1234
```

2.3 CONSOLE COMMAND DESCRIPTIONS

Each console command description is divided into three, four, or five descriptive segments, depending on the particular command. The descriptive segments are:

- a. Syntax: describes the command structure
- b. Command description: a brief paragraph describing command operation, general restrictions, or available options
- c. Response: a description of the console program response to the specified command
- d. Qualifiers: a list of applicable command modifiers
- e. Options: a list of applicable command options.

The descriptive segments use the terms and symbols defined in Table 2-1. Note that every command (or command line) must be terminated with a <CR>.

2.3.1 Boot Command (B)

Syntax: BOOT [<device name>] <CR>

The boot command initiates a VAX-11/780 system bootstrap sequence. The command may support bootstrap operations from a set of alternate system devices.

<device name> has the following format: DDn, where DD is a two-letter device mnemonic (e.g., DX for floppy), and n is a one-digit unit number.

If no <device name> is given with the boot command, the console will perform the boot sequence for the default system device by executing an indirect command file named DEFBOO.CMD. This indirect file contains the necessary console commands to boot from whichever device is chosen to be the default system device.

If <device name> is given with the command, the console will execute an indirect command file named DDNBOO.CMD, where DDN is the <device name> given.

Example

BOOT RP0 -- will cause the console to execute an indirect command file named RP0BOO.CMD (console enters program I/O mode after executing the command file).

Bootstraps from devices other than the system default device are performed by indirect command files containing the console commands necessary to boot an alternate device. After successful CPU bootstrap completion, a response from VMS will be displayed on the console terminal.

2.3.2 Clear Command (CL)

Syntax: Clear<BLANK>(SOMM ! Step)

CLEAR SOMM The Stop on Microbreak Match (SOMM) enable on the console interface board is cleared -- (disabled).

CLEAR STEP Any existing clock step mode (single bus cycle, single time state, single instruction) is cleared, and the VAX-11/780 CPU clock will be in the normal (free-running) mode.

Response: <CR><LF><CONSOLE-PROMPT>

2.3.3 Continue Command (C)

Syntax: CONTINUE <CR>

The continue command causes the VAX-11/780 CPU to begin instruction execution at the address currently contained in the CPU program counter (PC). Note that CPU initialization is not performed. The console enters the program I/O mode after issuing the continue command.

Response: <CR> <LF> (console enters program I/O mode)

2.3.4 Deposit Command (D)

Syntax: DEPOSIT [<qualifier - list>] <blank> <address> <blank> <data> <CR>

Qualifiers: /BYTE, /WORD, /LONG, /QUAD, /NEXT, /VIRTUAL, /PHYSICAL, /V BUS, /INTERNAL, /GENERAL. (Refer to Paragraph 2.7 for description of defaults.)

The deposit command writes (deposits) <data> into the address specified. The address space used will depend on the qualifiers specified with the command. If no qualifiers are used, the current address type default will determine the address space to be used.

Response: <CR> <LF> <input prompt>

The <address> argument may also be one of the symbolic addresses defined in Table 2-2.

Table 2-2 Deposit Symbolic Addresses

Symbol	Definition
PSL	Deposits to the processor status longword
PC	Deposits to the program counter (general register F)
SP	Deposits to the stack pointer (general register E)
+	Deposits to the location immediately following the last location referenced. For physical and virtual references the location referenced will be the last address plus n, where n = 1 for byte, 2 for word, 4 for longword, 8 for quadword. For all other address spaces, n is always equal to 1.
-	Deposits to the location immediately preceding the last location referenced
*	Deposits to the location last referenced
@	Deposits to the address represented by the last data examined or deposited.
Example:	
E SP	Examines stack pointer
D @ <data>	Deposits <data> to the location specified by the contents of the stack pointer.

2.3.5 Enable DX1: Command

Syntax: Enable DX1:

Qualifiers: None

Enable console software to access floppy on those systems with dual floppies.

Response: <CR><LF> <INPUT-PROMPT>

2.3.6 Examine Command (E)

Syntax: EXAMINE [<qualifier - list>] [<blank> <address>] <CR>

Qualifiers: /BYTE, /WORD, /LONG, /QUAD, /NEXT, /VIRTUAL, /PHYSICAL, /ID BUS, /V BUS, /INTERNAL, /GENERAL. (Refer to Paragraph 2.7 for description of defaults.)

The examine command reads and displays the contents of the specified <address>. If no <address> is specified, the current <default address> is examined.

The <address> argument may also be one of the symbolic addresses defined in Table 2-3.

Table 2-3 Examine Symbolic Address

Symbol	Definition
PSL	Displays the processor status longword
PC	Displays the program counter (general register F)
SP	Displays the stack pointer (general register E)
+	Displays the location immediately following the last location referenced.
-	Displays the location immediately preceding the last location referenced
*	Displays the last location referenced
@	Displays the location whose <address> is the last data examined or deposited.

Response: <CR> <LF> <tab> <address space identifier> <address>
<data> <CR> <LF> <input prompt>

Sample responses (console output underlined)

```
>>> EXAMINE/PHYSICAL 1234
P 00001234      ABCDEF89
>>> EXAMINE/VIRTUAL 1234
P 00005634      01234567
```

NOTE

The translated physical address is displayed for virtual examines.

```
>>> EXAMINE/G 0
G 00000000      98765432; GPR 0
```

2.3.7 Halt Command (H)

Syntax: HALT <CR>

The halt command causes the VAX-11/780 CPU ISP to stop instruction execution after completing execution of the instruction being executed, when the console presents the halt request to the VAX-11/780 CPU.

Response: (VAX-11/780 CPU indicates it has stopped) <CR> <LF>
<tab> HALTED AT <contents of VAX-11/780 CPU PC> <CR> <LF> <input prompt>

2.3.8 Help Command (HE)

Syntax: HELP <CR>

The console opens an indirect command file that displays a console help file, CONSOLE.HLP. The help file contains a description of all console commands and console abbreviation rules, and it lists the names of all other help files that may be displayed.

Response: Help file printed on console terminal.

2.3.9 Initialize Command (I)

Syntax: INITIALIZE <CR>

This command causes VAX-11/780 CPU system initialization.

Response: <CR> <LF> <tab> INIT SEQ DONE <cr> <LF> <input prompt>

2.3.10 LINK Command (LI)

Syntax: Link

Qualifiers: None

Link causes the console to begin command linking. Console prints reversed prompt to indicate linking. All commands typed by user are then stored in an indirect command file for later execution. Control C terminates linking.

Response: <CR><LF><REVERSE-PROMPT>

(Refer to Paragraph 2.9 for further details.)

2.3.11 Load command (LO)

Syntax: LOAD [<qualifier list>] <blank> <file specification> <CR>

The load command is used to read file data from the console's floppy disk to the VAX-11/780 main memory, or Writable Control Store (WCS). The applicable qualifiers are defined in Table 2-4. If no qualifier is given with the load command, physical main memory is loaded.

Table 2-4 Load Command Qualifiers

Qualifier	Definition
/START: <address>	This qualifier specifies a starting address for the load. If no start qualifier is given, the console will start loading at address 0.
/WCS	This qualifier specifies that the WCS is to be loaded.

2.3.12 Perform Command (P)

Syntax: Perform

Qualifiers: None

The perform command executes a file of linked commands previously generated by a link command.

Response: <dependent on commands linked>

2.3.13 Quad Clear Command (Q)

Syntax: QCLEAR <blank> <physical address> <CR>

The quad clear command clears the quadword at the <address> specified. The command is used to clear an uncorrectable ECC error. The <address> is always interpreted as a physical main memory location. The <address> given is forced to a quadword boundary by the unconditional clearing of the three low-order address bits.

2.3.14 Reboot Command (REB)

Syntax: REBOOT

Qualifiers: None

This command causes a console software reload, without disturbing the VAX-11/780.

Response: <console start-up display>

2.3.15 Repeat Command (R)

Syntax: REPEAT <console command> <CR>

A repeat command causes the console to repeatedly execute the specified <console command> until execution is terminated by a Control C (^C) (Paragraph 2.8). Any valid console command may be specified for <console command> with the exception of the repeat command.

Response: Dependent on command specified.

2.3.16 Set Command (SE)

Syntax: SET <blank> DEFAULT [<blank> <default option>] <CR>
or
SET <blank> STEP [<blank> <step option>] <CR>
or
SET <blank> TERMINAL <blank> (fill: <count>! PROGRAM) <CR>
or
SET <blank> SOMM <CR>
or
SET <blank> CLOCK [<blank> (SLOW! FAST! NORMAL)] <CR>
or
SET RELOCATION: <data> <CR>

Response: <CR> <LF> <input prompt> (for all commands)

The set default command sets console default for radix of console numeric input and output, address type, and data length. The console will apply defaults when a console command does not explicitly specify radix, address type, or data length. A set default command with no options specified will set all default settings to the power-up state. Applicable default options are listed in Table 2-5.

Table 2-5 Set Default Command Options

Option	Format	Specification
Address Default Options	Physical Virtual General Internal ID Bus V Bus	Sets default addressing mode as specified
Data Default Options	Long Byte Word Quad	Sets default data length as specified
Default Radix Options	Hex Octal	Sets default radix for terminal numeric I/O to radix specified

The set step command sets the VAX-11/780 CPU processor clock mode to the mode specified. The applicable modes are listed in Table 2-6.

Table 2-6 Set Step Command Options

Option	Specification
Step Step Instruction	Sets CPU clock mode to single instruction step mode
Set Step Bus	Sets CPU clock mode to single SBI cycle step mode
Set Step State	Sets CPU clock mode to single SBI time state step mode

The set terminal command allows the selection of two parameters.

- a. Set Terminal Fill: <count> = The count specifies the number of fill characters to be added after special characters (e.g., prompts) are transmitted to the console terminal.
- b. Set Terminal Program = The console terminal enters the program I/O mode.

The set clock command sets the VAX-11/780 CPU clock to a frequency specified by one of the arguments (Fast, Slow, Normal) within the command where:

Fast = 10.525 MHz
 Slow = 8.925 MHz
 Normal (or no argument) = 10.0 MHz

The set SOMM command sets the Stop on Microbreak Match (SOMM) enable on the console interface board (CIB). When SOMM is set, if the contents of the VAX-11/780 micro PC ever become equal to the contents of the microbreak match register (ID register 21), the CPU clock is stopped.

The set relocation command deposits <data> to the console's relocation register. The contents of the relocation register are added to the effective address of all virtual and physical memory examines and deposits.

Response: <CR><LF><input-prompt>

2.3.17 Show Command (SH)

Syntax: SHOW <CR>

The show command will cause the console terminal to display:

- a. The current default settings for data length, address type, and radix of address and data inputs and outputs.
- b. The terminal fill character count.
- c. The VAX-11/780 CPU status including the run/halt state and current clock mode setting.

2.3.18 Start Command (S)

The two start command formats are described below.

Syntax: START <blank> <address> <CR>

This format performs the equivalent of the following sequence of console commands:

1. Performs a VAX-11/780 CPU initialization (>>> INIT).
2. <address> is deposited into the VAX-11/780 PC (>>> DEPOSIT PC <address>).
3. A continue function is issued to begin VAX-11/780 CPU instruction execution (>>> CONTINUE).

Response: <CR><LF> (console enters program I/O mode) (for START)

Syntax: START/WCS <blank> <address>

This format performs the equivalent of the following sequence of commands:

1. <address> is deposited to the VAX-11/780 micro PC.
2. CPU clock is started in free-running mode.

Response: <CR><LF> <input prompt> (for START/WCS)

2.3.19 Next Command (N)

Syntax: NEXT [<blank> <count>] <CR>

The next command causes the VAX-11/780 CPU clock to step the number of times indicated by <count>. The type of step performed by the clock is determined by the current state of the CPU clock mode, as set by a previous set step command. A next command issued while the VAX-11/780 CPU is in normal (free-running) mode will default to single instruction step mode for the duration of the command.

The console enters program I/O mode immediately before issuing the step, and reenters console I/O mode as soon as the step is completed. Step-dependent responses are displayed on the console terminal after the completion of each of the count steps as specified below.

- a. Single instruction step:
 <CR> <LF> <tab> HALTED AT <contents of PC>
- b. Single bus cycle step:
 <CR> <LF> <tab> CPT0 UPC = <contents of UPC>
- c. Single time state step:
 <CR> <LF> <tab> CPTn (where n = 1, 2, or 3) or
 <CR> <LF> <tab> CPT0 UPC = <contents of UPC>

If no <count> is specified, one step is performed, and the console enters the space bar step mode. While in this mode, each depression of the space bar causes one execution of the step option currently enabled (i.e., bus cycle, time state, instruction).

A next command with an argument will not enable the space bar feature. For example, NEXT 2 will cause two steps to be executed; the console will then prompt for another command.

An input of any character except SPACE will cause an exit from the space bar step mode.

2.3.20 Test Command (T)

Syntax: TEST [/COMMAND] <CR>

This command invokes the microdiagnostic monitor program. If no /COMMAND qualifier is issued with the command, microdiagnostic execution begins immediately. If microdiagnostic testing is completed successfully (i.e., no errors detected) the console program is invoked automatically.

The COMMAND qualifier is used to cause the microdiagnostic monitor to enter its command mode and wait for operator input before initiating microdiagnostic execution.

2.3.21 Unjam Command (U)

Syntax: UNJAM <CR>

This command initiates an SBI unjam operation.

Response: >>>

2.3.22 Wait Command (WA)

Syntax: WAIT <blank> DONE

The wait command has no effect unless it is executed from an indirect command file. When it is executed from an indirect

command file, it causes further execution of the command file to be suspended until one of the following occurs:

- a. A DONE signal is received from a program running in the VAX-11/780 CPU. On receipt of DONE, the console will resume execution of the command file.
- b. If the VAX-11/780 CPU halts (or if the clock stops) and no DONE signal has been received, the console prints <@EXIT> and aborts execution of the remainder of the command file.
- c. A Control C (^C) is entered on the console terminal, which causes the console to abort execution of the command file.

Response: <CR> <LF> <input prompt>

2.3.23 Indirect (@) Command

Syntax: @ <filename> <CR> or @ DX1: <filename> <CR>

This command causes the console to open the file specified by <filename> and begin executing console commands from the file. Execution continues until one of the following occurs:

- a. A WAIT DONE command is read from the file (Paragraph 2.3.22).
- b. The end of the indirect file is reached. In this case the console prints <@EOF> and prompts for normal command input.
- c. A ^C is entered on the console causing it to abort execution of the indirect file.

2.3.24 WCS Command (W)

Syntax: WCS

This command invokes the control store debugger, overlaying the console program. The console help file, WCSMON.HLP, contains a summary of control store debugger commands. To print out this file, type @ WCSMON.HLP.

Response: WCS> (Control store debugger prompt)

2.4 COMMANDS PERFORMED WITH THE VAX-11/780 CPU RUNNING

Most console commands require that the VAX-11/780 CPU be halted to allow the command to be executed. However, some console commands do not require interaction with the VAX-11/780 CPU, and may be executed with the VAX-11/780 CPU running. These commands include:

- | | |
|-------------------|--------------|
| a. Show | e. Halt |
| b. Help | f. Clear |
| c. Set commands | g. Wait Done |
| d. Examine /V Bus | |

Specifying any other console command while the VAX-11/780 CPU is running will cause the console adapter to reject the command and type out the following error message on the console terminal:

```
<CR> <LF> ? CPU NOT IN CONSOLE WAIT LOOP, COMMAND ABORTED
<CR> <LF> <INPUT PROMPT>
```

2.5 COMMENTS WITHIN COMMANDS

The console allows comments, preceded by an exclamation mark (!), to appear in any command line. When the console detects an exclamation mark, any remaining text in the command line is ignored.

A comment may begin in any character position within a command line, including the first.

Example (console output underlined)

```
>>> ! THIS IS A VALID COMMENT <CR>
>>> EXAMINE 1234 ! THIS IS ALSO A COMMENT <CR>
```

2.6 CONTROL CHARACTERS AND SPECIAL CHARACTERS

Table 2-7 contains a description of the control characters and special characters recognized by the console program.

Table 2-7 Control/Special Character Descriptions

Character	Description
CONTROL C (^C)	<p>Causes the suspension of all repetitive console operations such as:</p> <ol style="list-style-type: none"> Repeated command executions as a result of a repeat command Successive operations as a result of a /NEXT qualifier Delays resulting from a wait command Successive steps resulting from a next command Aborts further execution of an indirect command file after current instruction is completed.
CONTROL O (^O)	<p>Suppresses or enables (on a toggle basis) console terminal output. Console terminal output is always enabled at the next console terminal input prompt.</p>

Table 2-7 Control/Special Character Descriptions (Cont)

Character	Description
CONTROL U (^U)	<p>^U typed before a line terminator causes the deletion of all characters typed since the last line terminator. The console echoes:</p> <p>^U <CR> <LF></p>
RUBOUT	<p>Typing RUBOUT deletes the last character typed on an input line. Only characters typed since the last line terminator can be rubbed out. Several characters can be deleted in sequence by typing successive rubouts. The first rubout echoes as a backslash (\) followed by the character that has been deleted. Subsequent rubouts cause only the deleted character to be echoed. The next character typed that is not a rubout causes another backslash (\) to be printed, followed by the new character to be echoed.</p>
Carriage Return <CR>	<p>Terminates a console command line.</p>

2.7 COMMAND QUALIFIERS AND DEFAULTS

Qualifiers are used within a command to specify the type of addressing and the length of data arguments. Defaults are applied by the console when a command does not contain a qualifier specifying address-type or data length. An operator can specify the radix of a numeric argument by the use of a <local radix override> prefixed to the argument. The console will interpret numeric arguments in the current default radix when an argument is not prefixed by a <local radix override>.

Certain commands permit an address argument to be defaulted. The <default address> used by the console is the next address following the last virtual, physical, or register address accessed by an examine or deposit command. Note that the next address is dependent upon data length, since a byte reference updates the <default address> by 1, while a longword reference updates the <default address> by 4.

The /NEXT qualifier allows an examine or deposit command to operate on more than one address.

2.7.1 Address Type Qualifiers

Address type qualifiers are used within a command line to specify the type of address argument as virtual, physical, ID Bus, V Bus or register address. The qualifiers for the respective types are: /VIRTUAL, /PHYSICAL, /ID BUS, /V BUS, /GENERAL, /INTERNAL.

Virtual addresses that reference nonexistent or nonresident pages will cause the console to abort execution of the console command that referenced the virtual address. In each case an appropriate error message will be typed out on the console terminal.

Example

To examine virtual address 1234, type:

```
EXAMINE/VIRTUAL 1234 <CR>
```

Note that since some register addresses have mnemonic names that are unique and unambiguous, the /GENERAL qualifier need not be specified when mnemonic addresses such as PC, or SP, are referenced.

Example

To examine the VAX-11/780 PC, an operator could type either of the following statements:

```
EXAMINE/GENERAL PC <CR> or  
E PC <CR> or  
E GENERAL F <CR>
```

2.7.2 Address Type Defaults

The console applies an address type default to any command that requires an address argument and does not contain an address qualifier. The default applied can be set by using the set default command.

Example

The command:

```
SET DEFAULT VIRTUAL <CR>
```

will cause the console to default to virtual addressing for any console command that requires an address argument, but does not contain an address type qualifier. Thus, the command EXAMINE 1234 would type out the contents of virtual address 1234.

2.7.3 Data Length Qualifiers

Data length qualifiers are used within a command line to specify the length of the data quantity associated with the command. Data length may be specified as either byte, word, longword, or quadword by means of the /BYTE, /WORD, /LONG, /QUAD qualifiers, respectively.

Example

The command:

```
EXAMINE/BYTE 1234 <CR>
```

will type out the byte at address 1234.

Since VAX-11/780 CPU general and processor registers are longword quantities, all register references will default to longword data length, regardless of the current setting of the data length default.

2.7.4 Data Length Defaults

The console applies a data length default to any command that references data and does not contain a data length qualifier. The default applied can be set using the set default command.

Example

The command:

```
SET DEFAULT WORD <CR>
```

will cause the console to default to word data length.

The command:

```
EXAMINE 1234 <CR>
```

will then reference the word which has its first byte at address 1234.

Since all VAX-11/780 CPU general and processor registers are longword quantities, all register references will default to longword data length, regardless of the current setting of the data length default. Word length must be specified when accessing Unibus device registers.

2.7.5 Qualifiers for RADIX

The radix of console output for a command can be specified by a qualifier (/OCTAL or /HEX). The qualifier will override the current default radix.

2.7.6 Defaults for RADIX

The default radix for console numeric inputs and outputs is selectable as either HEX or OCTAL via the SET DEFAULT HEX or SET DEFAULT OCTAL command.

2.7.7 Local Radix Override

It is frequently convenient to specify an address or data argument in a radix different from the current default radix. The console allows the current default radix to be overridden by including a <local radix override> as a prefix to any numeric argument. A <local radix override> can be any one of the following:

% O (percent O) for octal arguments

% X (percent X) for hexadecimal arguments

The local radix override must appear as the two leftmost characters of the numeric argument it modifies, and must not be separated by spaces or tabs from that argument.

Example

Assuming that the current default radix is octal, the operator can deposit the octal value 3456 into the hexadecimal address 12A4 using <local radix override> as follows:

```
DEPOSIT %X12A4 3456
```

2.7.8 Default Address Facility

Each time an examine or deposit command is executed, the console computes the address of the next memory location following the location referenced by the command. The address of the next memory location is termed the <default address>, since an examine command

that does not specify an address will reference the next address by default. The console computes the <default address> as follows:

<default address> = <address used by last examine or deposit command> + n, where n is
1 for byte references
2 for word references
4 for longword references
8 for quadword references

The following example shows a sequence of console commands, and the value taken by the default address after each command is executed. Note that the next address is data length dependent, since a byte reference updates the <default address> by 1, while a longword reference updates the <default address> by 4.

Example of default address facility (all numbers are hex):

Command	<default address> after execution
EXAMINE/BYTE 2341	2342
EXAMINE/WORD (uses <default address> 2342)	2344
EXAMINE/LONG (uses <default address> 2344)	2348
EXAMINE/GENERAL 0	general register 1 (R1)
EXAMINE/GENERAL D	general register E (SP)
EXAMINE PC	general register 0 (R0)

Note that the <default address> is R0 following a PC reference.

2.7.8.1 Specifying Default Address in a Command -- The symbol (+) can be used as an address argument in a deposit or examine command to represent the <default address>. This symbol permits depositing to (or examining) successive location without typing the address argument after the first deposit.

Example

To toggle-in a program starting at address 123456, the following deposit commands can be used:

```
DEPOSIT    123456    <DATA>
DEPOSIT    +         <DATA>
DEPOSIT    +         <DATA>
```

Each deposit command, after the first, writes the <DATA> into the next successive memory location.

2.7.8.2 Last Address Notation -- The last address referenced (virtual, physical, or register) by an examine or deposit command is denoted by an asterisk (*). The LAST ADDRESS may be used as an argument to an examine or deposit command by typing an asterisk in place of the address argument.

Example

The command:

```
EXAMINE 1234 <CR>
```

will type out the contents of location 1234.

If the next command issued is

```
DEPOSIT * 356 <CR>
```

the console will deposit the number 356 into location 1234.

Examine and deposit commands to VAX-11/780 CPU general and processor registers will replace the <last address> with the register address. Mnemonic register names are translated into register addresses by the console.

2.7.8.3 Preceding Address Notation -- The symbol - (minus sign) can be used as an address in a deposit or examine command to specify the location immediately preceding the last location referenced.

2.7.8.4 Use of Last Data as an Address Argument -- The symbol @ can be used as an <address> in a deposit or examine command. The last <data> deposited or examined will be used as the address.

2.7.9 NEXT Qualifier

Syntax: SLASH NEXT [:<COUNT>]

The /NEXT qualifier permits examine and deposit commands to operate on multiple sequential addresses.

The <count> argument specifies the number of additional executions of the command to be performed after the initial execution. The default value for <count> is one.

Example 1

The command:

```
EXAMINE/BYTE 1230/NEXT:2
```

is evaluated by the console as follows:

1. The console initially evaluates the command and applies any applicable default values.
2. The command, with applied defaults, is executed. The console types out the contents of location 1230, and updates the <default address> to 1231.

3. The /NEXT switch is now evaluated by the console. The console repeats the command operation the number of times indicated by the <count> argument. Each execution uses the <default address> for its address argument and updates the <default address> afterwards. In this example, locations 1231 and 1232 are successively typed out. The final value of the <default address> will be 1233.

Example 2

If the command:

```
EXAMINE/NEXT:2 <CR>
```

is issued following the command in the previous example, the contents of locations 1233, 1234, and 1235 will be typed out. Since the examine command does not contain an address argument, the initial execution of the command will use the current <default address>, which was 1233, following the command in the previous example.

Note that when using the /NEXT qualifier to examine or deposit successive VAX-11/780 CPU general registers, the NEXT register after the PC is defined to be R0.

Example 3

The command:

```
EXAMINE/NEXT:5 GENERAL D
```

will type out the contents of R13, SP, PC, R0, R1, and R2, in that order.

2.8 COMMAND REPEAT FACILITY

The command repeat facility is provided to allow commands to be executed repeatedly so that CPU logic invoked by console commands can easily be scoped. The following paragraphs describe the repeat facility commands and capabilities.

2.8.1 Repeating Commands

Example

The command:

```
REPEAT EXAMINE 1234 <CR>
```

will continuously examine and display the contents of location 1234.

Once initiated, repeated execution continues until terminated by the operator typing Control C (^C) on the console keyboard.

2.9 COMMAND LINK FACILITY

The console's command link facility allows successive commands to be linked by the console into a single executable list of commands. Once a list of linked commands is constructed, the list can be executed one pass at a time, or executed continuously.

2.9.1 Link Facility Operation

Commands are linked by entering LINK on the console terminal, causing the console to enter the link mode. LINK is then followed by the desired commands. The LINK command is entered only at the beginning of the command string (i.e., at the beginning of the initial command line). Commands to be linked must be entered one-per-line, with each command line terminated by a <CR>. The console then returns a link mode prompt (<<<) requesting the next command. The linking operation is terminated by entering a Control C on the console.

As the command string is entered on the console, the commands are stored in dedicated sectors (limit of 10 sectors) on the floppy disk (RX01). When the command string is executed, the string is treated as if it were an indirect command file (i.e., command retrieved, parsed, executed, and the next command retrieved, etc.).

The console does not execute commands being linked until a PERFORM command is issued. Once the input of a list of linked commands has been terminated, no further commands can be added to the commands already linked.

The command string can be executed one pass at a time or continuously by means of the PERFORM command. If the PERFORM command is entered after the Control C to terminate the string, the string will execute only one pass. However, if PERFORM is entered before the Control C, that command becomes part of the command list and causes continuous execution of the command list.

Should a linked command be entered incorrectly, the console will output an appropriate error message when the command containing the syntactic error is executed. Typing a Control U (^U) while linking commands will cause the console to reject only the current command line.

2.9.2 Link Facility Usage

Syntax: LINK
COMMAND <CR>
COMMAND <CR>
<^C>

Response: Dependent on command list.

Example

The operator wishes to repeatedly examine the contents of a device register after VAX-11/780 CPU initialization. Since

the CPU initialization requires a certain amount of time to complete, a delay must be inserted between the initialize and examine commands. The sequence of commands is as follows (console output is underlined).

<u>>>> LINK INITIALIZE <CR></u>	LINK causes the console to enter the link mode and begin linking.
<u><<< DELAY 5 <CR></u>	Delays five clock ticks to allow initialize time to complete.
<u><<< EXAMINE/LONG FFFFABBC <CR></u>	Examine command is entered into string.
<u><<< PERFORM <CR> <^C></u>	PERFORM is entered prior to linking termination.
<u>>>> PERFORM <CR></u>	Initiates execution.
<u>P FFFFABBC 12A00123</u> <u>P FFFFABBC 12A00123, etc.</u>	Command string executed continuously.

2.10 CONSOLE MODE CHANGE

The console I/O mode escape sequence causes the console to switch from console to program I/O mode. The escape sequence to program I/O is:

SET TERMINAL PROGRAM <CR>

In addition, the console commands START, CONTINUE, and NEXT also enable program I/O mode.

The program I/O mode escape sequence causes the console to switch from program to console I/O mode. The escape sequence to console I/O is:

Control P (^P)

Note that Control P is not recognized by the console if the console power switch is in either the REMOTE DISABLE position or the LOCAL DISABLE position.

2.11 VMS COMMUNICATION WITH CONSOLE FLOPPY DISK

VMS must be able to read and write the console subsystem's floppy disk drive. These functions are available only when the console is in program I/O mode. The following set of commands are supported by the console software.

- a. Write sector -- VMS supplies track, sector, and 128 bytes of data. Console returns status upon completion of write.

- b. Read sector -- VMS supplies track and sector. Console returns 128 bytes of data, and status of read operation.
- c. Read floppy status -- Console returns floppy status.
- d. Write sector with deleted data mark -- VMS supplies track and sector (no data required). Console returns status upon completion of the write.
- e. Cancel floppy function -- Console aborts current floppy function.

The following floppy functions will not be directly available to VMS: empty silo, fill silo, read error register, initialize.

While VMS initiated floppy functions are in progress, operator terminal I/O is not disabled. Terminal I/O may be interspersed with floppy I/O.

Once a floppy function is initiated, no other floppy commands will be issued by VMS until the function is complete. The only exception is the command cancel floppy function, which may be issued at any time.

The floppy functions described in this document will only be available to VMS when the console is in program I/O mode (i.e., the console terminal is being used as the system operator's terminal).

NOTE

In the following protocols, two hardware side-effects are implied:

1. Each time VMS loads the transmit buffer (TXDB), the TX ready bit in the transmit status register (TXCS) is automatically cleared. TXDB is only loaded by VMS, and only when TX ready is set. TX ready is explicitly set by the console when the console is ready to accept another transfer through TXDB.
2. Each time VMS reads the receiver buffer (RXDB), the RX done bit in the receiver status register (RXCS) will automatically clear. RXDB is only read by VMS, and only when RX done is set. RX done is explicitly set by the console each time the console has loaded RXDB with a character for VMS.

2.11.1 Floppy Function Protocol

A. Write sector/write deleted data sector

1. VMS puts the write sector or the write deleted data sector command into TXDB.
2. The console takes the write command, and sets TX ready in TXCS.
3. VMS puts a sector number into TXDB.
4. The console takes the sector number and sets TX ready.
5. VMS puts a track number into TXDB.
6. The console takes the track number and sets TX ready.
7. VMS puts a byte of data into TXDB.
8. The console accepts a byte of data and sets TX ready. Steps 7 and 8 are done 128 times for write sector. Steps 7 and 8 are skipped for write deleted data sector.
9. The console initiates a floppy write function.
10. The floppy write is completed.
11. The console sends a floppy function complete message. The floppy function complete message consists of loading RXDB bits 8--11 with a select code of 2, and bits 0--7 with the floppy status byte.
12. VMS receives the floppy function completed message.

B. Read sector

1. VMS puts the read sector command into TXDB.
2. The console takes the read command, and sets TX ready in TXCS.
3. VMS puts a sector number into TXDB.
4. The console takes the sector number and sets TX ready.
5. VMS puts a track number into TXDB.
6. The console takes the track number and sets TX ready.
7. The console initiates a floppy read function.
8. The floppy read is completed.

9. The console sends a floppy function complete message. The floppy function complete message consists of a select code of 2 in bits 8--11 of RXDB, and a floppy status byte in bits 0--7 of RXDB.
10. VMS receives the floppy function completed message.
11. The console puts one byte of data in RXDB and sets RX done.
12. VMS accepts one byte of data from RXDB. Steps 11 and 12 are done 128 times. When the 128th byte is accepted by VMS, the read is complete.

NOTE

If a floppy error occurs on Step 8,
Steps 11 and 12 will be skipped.

C. Read status

1. VMS puts the read floppy status command in TXDB.
2. The console takes the read status command and sets TX ready in TXCS.
3. The console gets the floppy status from last floppy function performed.
4. The console puts a floppy function complete message, with the floppy status, into RXDB and sets RX done.
5. VMS reads the floppy status.

D. Terminate floppy function

1. VMS puts the cancel floppy function command in TXDB.
2. The console takes the cancel floppy function.
3. The console terminates the floppy function in progress, if any.
4. The console sets TX ready in TXCS.

2.12 MISCELLANEOUS CONSOLE COMMUNICATIONS

The console software will support certain additional functional communications from VMS and the diagnostic supervisor (VMS/DS).

- A. **Examine console memory** -- VMS supplies an offset from the console-supplied base address of examinable memory space. The console returns the examine code and the contents of the requested byte.

Examinable Console Memory Space

(Octal Offset from 37600(8) -- FIRSTF)

+145	Warm-start flag
+146	Cold-start flag
+147	APT-load flag
+150	Last setting of remote and disable
+151	Auto-restart flag
+152	PCS version
+153	WCS primary version
+155	FPLA version

B. Software communication codes

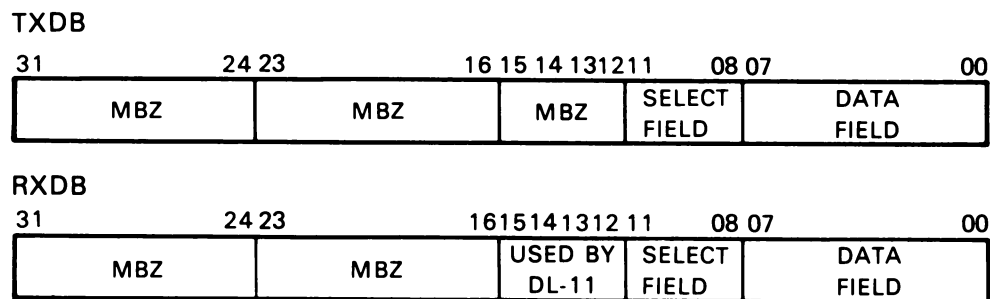
1. Software done -- VMS issues this code to cause the console to resume execution of an indirect-command file that has been suspended due to a wait done command.
2. Warm restart boot command -- The console will boot the VAX-11/780.
3. Clear warm-start and cold-start flags -- VMS/DS issues these codes when the VAX has restarted/rebooted successfully. The console clears the associated flags.

NOTE

The cold and warm restart flags are used by the console to prevent infinite loops when a warm restart results in a VAX-11/780 error halt.

2.13 COMMUNICATION REGISTER FORMATS AND SELECT CODES

The LSI-11 processor communicates with the VAX-11/780 CPU via two registers on the console interface board. Figure 2-1 shows the register formats and select codes.



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Figure 2-1 Communication Register Formats and Select Codes

Select Field Values (in hex)

Select Code	Device	Data Field Values
0	Operator's terminal	0 through 7F ! ASCII data
1	Floppy drive 0 (data)	0 through FF -- binary data
2	Floppy function complete	(floppy status)
3	Examine console memory	Address offset/contents of address
9	Floppy drive 0 (command)	0 = read sector 1 = write sector 2 = read status 3 = write deleted data sector 4 = cancel floppy function 5 = protocol error
F	Misc. communication	1 = software done 2 = boot VAX-11/780 3 = clear warm-start flag 4 = clear cold-start flag

NOTE

Code 5 (protocol error) is sent by the console when one of the following occurs:

1. Another floppy command (except for cancel floppy function) is issued by VMS before a previous command is completed.
2. The console gets a floppy drive 0 code (DATA) when expecting a command.

2.14 FLOPPY STATUS BYTE DEFINITION

The floppy status byte is used by VMS to determine the success or failure of a read or write operation. The floppy status byte is sent to VMS at the completion of a read, write, or read status operation. The select code is always the floppy function complete (code 2). The status bit assignments are shown in Figure 2-2.

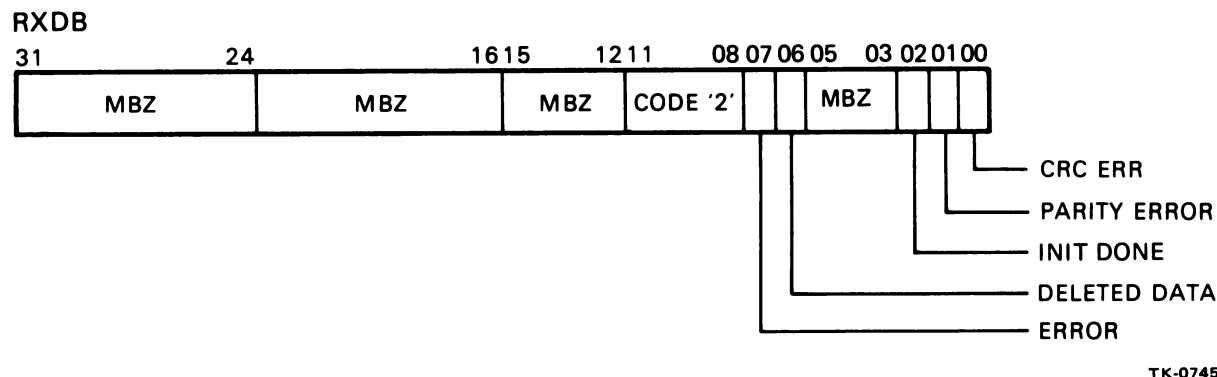


Figure 2-2 Floppy Status Bit Assignments

NOTE

The status bit assignments are identical to those supplied by the floppy controller, except for bit 7. Bit 7 corresponds to bit 15 of the floppy's RXCS register.

2.15 REMOTE CONSOLE ACCESS COMMAND SET

A special set of commands is included in the console command language of systems that use the remote diagnostic facility to facilitate console access from a remote terminal or computer. Commands can be initiated only on the terminal in control, according to the five-position key switch. The remote access command set provides for:

- A talk mode, to allow communication between local and remote terminal operators (enable talk).
- A copy control, to permit suppressing or enabling typeout on the local terminal while a remote operator is in control (enable/disable local copy).
- A method of transferring control of the console between the local and remote operators (enable local control).

- d. A method of controlling the echo of characters to the remote terminal while in talk mode (enable/disable echo).
- e. A method of suppressing lost carrier error messages caused by a loss of carrier on the remote line (enable/disable carrier error).
- f. A method of enabling and disabling use of the console subsystem floppy disk (enable/disable local floppy).
- g. A method of enabling and disabling use of the remote floppy disk (enable/disable remote floppy).

2.15.1 Enable Talk Mode Command

Syntax: ENABLE <blank> TALK <CR>

The enable talk command puts the console into talk mode. While in talk mode, characters typed on the remote keyboard are typed on the local terminal, and vice versa. The console does not echo characters back to the originating keyboard, unless the talk mode echo feature has been enabled. No console commands are recognized while in talk mode.

Talk mode is terminated by typing the console escape character (^P) on the terminal in control. When talk mode is terminated, console mode is enabled.

Entering talk mode causes the console to enable the remote serial interface and assert the data terminal ready signal to the data set. All terminal I/O to a program running in the VAX-11/780 CPU is disabled while the console is in the talk mode.

2.15.2 Enable/Disable Echo Command

Syntax: (ENABLE ! DISABLE) <blank> ECHO <CR>

The enable echo command will cause the console to echo characters typed on either the remote or local keyboards while in talk mode. The disable echo command causes the console to suppress echo of characters typed on both keyboards.

Enable and disable echo are issued while the console is in console mode, but do not have any effect until talk mode is entered. A disable echo is automatically done each time the console keyswitch is put in the LOCAL/DISABLE position, and on power up of the console.

2.15.3 Enable/Disable Local Copy Command

Syntax: (ENABLE ! DISABLE) <blank> LOCAL <blank> COPY

The enable local copy command causes the local terminal to print a copy of all output directed to the remote terminal. The disable local copy command disables the local terminal from getting a copy of output directed to the remote terminal.

Local copy is automatically disabled each time the console keyswitch is turned to the LOCAL or LOCAL/DISABLE position and on power up of the console. Local copy is automatically enabled each time the console keyswitch is placed in the REMOTE/DISABLE position.

2.15.4 Enable Local Control Command

Syntax: ENABLE <blank> LOCAL <blank> CONTROL <CR>

An enable local control command, issued by the remote terminal operator while the console keyswitch is in the REMOTE position, transfers control of the console to the local terminal operator. (Normal remote operation locks out the local terminal.) This allows a local operator to take control of the console and the VAX-11/780 CPU, while the remote link is maintained. The remote operator may regain control of the console by typing a Control P on the remote keyboard.

An enable local control command issued from the local terminal has no effect. Local control is automatically enabled when the console keyswitch is placed in the LOCAL or LOCAL/DISABLE position, and also on console power up.

2.15.5 Enable/Disable Carrier Error Command

Syntax: (ENABLE ! DISABLE) <blank> CARRIER <blank> ERROR <CR>

The enable carrier error command causes the console to print the message ?CARRIER LOST each time a loss of carrier on the remote line is detected. Also, if the console keyswitch is in the LOCAL or REMOTE position, the console enters talk mode, enabling data terminal ready on the modem.

The disable carrier error command causes the console to inhibit the carrier lost message, and prevents a transition to talk mode. An enable carrier error is automatically done on console power up, and whenever the console keyswitch is placed in the LOCAL or LOCAL/DISABLE position.

2.15.6 ENABLE/DISABLE LOCAL Floppy Command

Syntax: (ENable!Disable)<BLANK>Local<BLANK>Floppy

Enable local floppy will cause the directory of the local floppy to be searched first, in an attempt to open a file. If the file is not found, the remote floppy directory is searched. Note that in terms of the console software, the remote floppy is a virtual device. It may be a floppy or it may be some other storage device.

Disable local floppy will cause only the directory of the remote floppy to be searched in an attempt to open a file.

An enable/disable local floppy command affects protocol operation only (transmission format).

2.16 CONSOLE ERROR MESSAGES

This paragraph describes all console error message formats and their interpretation. All console error messages are prefixed by a question mark to distinguish them from informational messages.

2.16.1 Syntactic Error Messages

?<TEXT STRING> IS INCOMPLETE

The <TEXT STRING> is not a complete console command.

?<TEXT STRING> IS INCORRECT

The <TEXT STRING> is not recognized as part of a console command.

?FILE NAME ERR

A <FILENAME> given with a LOAD or @ command cannot be translated to RAD50. One of the characters is not translatable to RAD50 or the number of characters allowed is exceeded: six characters for file name, three for extension.

2.16.2 Command Generated Error Messages

?FILE NOT FOUND

A <FILENAME> given with a LOAD or @ command does not match any file on the current floppy disk. This error can also be generated by a HELP or BOOT command if the help file or boot file is missing from the floppy.

?NO CPU RESPONSE

The console timed out while waiting for a response from a VAX-11/780 CPU microroutine.

?CPU NOT IN CONSOLE WAIT LOOP, COMMAND ABORTED

A console command that required the assistance of the VAX-11/780 CPU was issued when the CPU was not in the console service loop.

?CPU CLOCK STOPPED, COMMAND ABORTED

A console command that requires the CPU clock to be running was issued with the clock stopped.

?IND-COM ERR

An indirect command file error was detected. This error is generated if:

- a. An indirect command line exceeds 80 characters.
- b. An indirect command line does not end with <CR> <LF>.

2.16.3 Microroutine Error Messages

The console uses various microcode routines in the VAX-11/780 CPU control store to perform console functions. The following errors are generated by microroutine failures.

?MEM-MAN FAULT, CODE = XX

A virtual examine or deposit caused an error in the memory management microroutine. XX is a one-byte error code supplied by the memory management routine and defined in Table 2-8.

NOTE

Bit positions are numbered from the right.

Table 2-8 Memory Management Error Code Definitions

Bit Position	Definition
0	Length violation
1	Fault was on a PTE reference
2	Write or modify intent
3	Access violation
4--7	Ignored

?MICROMACHINE TIME OUT

This message indicates that the VAX-11/780 micromachine has failed to strobe interrupts within the maximum time period allowed.

?MIC-ERR ON FUNCTION

An unspecified error occurred in the CPU while servicing a console request. Referencing nonexistent memory will cause this error.

?INT-REG ERR

An error occurred while referencing one of the VAX-11/780 CPU internal (processor) registers. Specifying a register address that is too large will cause this error.

?MICROERR, CODE = XX

An unrecognized microerror occurred. The code returned by the CPU is not in the range of recognized error codes. XX is the one-byte error code returned by the microroutine.

2.16.4 CPU Fault Generated Error Messages

?INT-STACK INVLD

The VAX-11/780 CPU interrupt stack was marked invalid.

?CPU DBLE-ERR HLT

The VAX-11/780 CPU has done a double error halt.

?ILL I/E VEC

An illegal interrupt/exception vector was encountered by the VAX-11/780 CPU.

?NO USR WCS

An interrupt/exception vector to WCS was encountered, and no WCS exists.

?CHM ERR

A change-mode instruction was attempted from the interrupt stack.

2.16.5 RX01 Error Messages

?FLOPPY ERR, CODE = X

The console floppy driver (a part of the console software) detected an error. X is an error code (in hexadecimal) and is defined in Table 2-9.

Table 2-9 RX01 Error Message Code Definitions

Code	Definition
0	Floppy hardware error (i.e., CRC, parity, or a floppy firmware detected error).
1	An open file command failed to find the specified file.
2	The floppy driver queue is full.
3	A floppy sector was referenced that is out of the legal range of sector numbers.

?FLOPPY NOT READY

The console floppy drive failed to become ready when booting.

?NO BOOT ON FLOPPY

The console attempted to boot from a floppy that does not contain a valid boot block.

?FLOPPY ERROR ON BOOT

A floppy error was detected while attempting a console boot.

2.16.6 Miscellaneous Error Messages

INT PENDING

This is not actually an error (note absence of ?). The message indicates that an error was pending at the time that a console requested halt was performed. Type CONTINUE to clear interrupt.

?WARNING-WCS and FPLA VER MISMATCH

The microcode in the WCS is not compatible with the FPLA. This message is printed on each ISP START or CONTINUE. However, no other action is taken by the console.

?FATAL-WCS and PCS VER MISMATCH

The microcode in the PCS is not compatible with that in the WCS. ISP START and CONTINUE are disabled by the console.

?REMOTE ACCESS NOT SUPPORTED

This message is printed when the console mode switch enters a REMOTE position, and the remote support software is not included in the console.

?TRAP -4, RESTARTING CONSOLE

The console took a time-out trap. Console will restart.

?UNEXPECTED TRAP

Console trapped to an unused vector. Console reboots when operator types Control C.

?QBLOCKED

Indicates that the console's output queue is blocked. Console will reboot.

CHAPTER 3

DIAGNOSTIC SUPERVISOR AND CONTROL

This chapter describes the basic structure and operating characteristics of the diagnostic supervisor. In addition, operator commands and execution control functions are described. This description is applicable to macro testing, and while many similarities exist for the micros, this chapter does not include them (refer to Chapter 4).

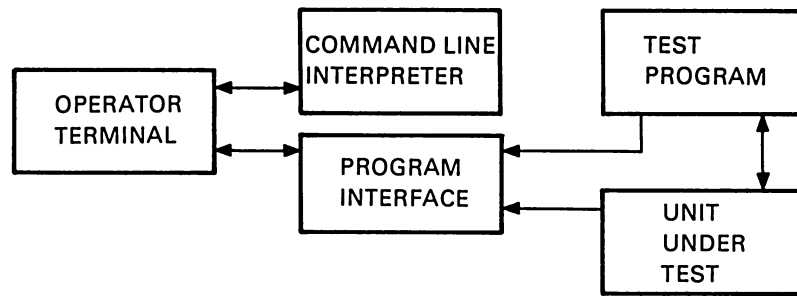
3.1 SUPERVISOR STRUCTURE OVERVIEW

The diagnostic supervisor provides operator control and utility support functions for three diagnostic runtime environments. The three runtime environments are:

- a. Cluster Environment (CE): This environment supports the CPU cluster and repair level I/O bus adapter diagnostic programs. The CE consists of program modules that provide utility services (i.e., error reporting, scope loops, etc.), initialization and test dispatch, and operator terminal interface. Additional modules provide load and script management.
- b. System Environment (SE): This environment supports the repair level I/O subsystem diagnostic programs, and the device functional test programs. The SE provides the same runtime support functions as the CE. Program modules provide CPU cluster hardware interface support (i.e., real-time clock control, interrupt system control, I/O bus adapter control, etc.).
- c. User Environment (UE): This environment supports the I/O subsystem functional level diagnostic programs that run under the VMS operating system as a privileged user task.

I/O services are provided primarily for functional level programs. This allows programs that can execute in an operating system environment, which restricts I/O access, to perform equally well in a standalone environment.

The three supervisor environments are assembled into a common executable module that provides all necessary operator and program services. As shown in Figure 3-1, these services are implemented in two major functional areas: Command Line Interpreter (CLI) and Program Interface (PGI).



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Figure 3-1 Basic Diagnostic Supervisor Structure

The CLI interfaces to an operator (controlling) terminal and enables the operator to control the loading, sequencing, and execution of diagnostic test programs. The CLI monitors all control information passing between the terminal and the supervisor. This information consists of supervisor commands from the operator which control either supervisor or test program operation. The CLI directs control to the appropriate supervisor service module according to the command supplied by the operator.

The PGI provides common services required by all diagnostic test programs. These services include operator interaction, program control, error message formatting, memory management, and I/O request handling. Note that the operator can communicate with the diagnostic program only through a PGI message service or with the CLI directly.

When the operator initiates diagnostic program execution (through the CLI), that program assumes control. Once program execution begins, the PGI handles all test information flowing between the terminal or the Unit Under Test (UUT) (i.e., QI/O-I/O driver interface) and a functional level program. For repair level programs, test information flows directly between the UUT and the diagnostic program (i.e., direct test program access to I/O registers).

Test control information flow between the terminal and the diagnostic program consists mainly of test parameter requests and responses, while test information flow between the UUT and the program consists mainly of test stimuli and responses.

The diagnostic program executes until the test sequence is completed, aborted, or the operator enters the appropriate control character, at which point control returns to the CLI.

System errors not directly related to the UUT are handled by the supervisor. Unless the program explicitly requests notification, these errors are transparent to the program and are reported directly to the operator.

3.2 CLI FUNCTIONAL MODULE DESCRIPTION

The CLI consists of a tree-structured command decoder and several service modules that execute the operator's commands (e.g., loading a diagnostic program from the system device; altering the operational characteristics of the program; or driving the CLI through a script file). The command syntax is a subset of the console command language.

Once a command line is interpreted, the CLI dispatches control to the appropriate service module. After the operator's command has been completed or aborted, control is returned to the CLI. Certain CLI service modules pass control to the diagnostic program, rather than back to the CLI. However, the CLI continues to monitor the operator's terminal for certain commands (e.g., ^C).

3.2.1 Image Loader Module

The image loader allows the operator to specify a load device and a file name for loading diagnostic programs. Depending on the environment (i.e., console, system, or user), the device media will be either the diagnostic load device (console floppy) or the system load device.

3.2.2 Test Sequence Control Module

The test sequence control module provides the operator with the capability to control the order in which tests within a program are executed. This is implemented by specifying test numbers in the run, start, and restart supervisor commands (Paragraph 3.4).

3.2.3 Script Processor Module

Automatic test sequence control is achieved through the use of a script file. This script file is a line-oriented ASCII file that contains standard CLI supervisor commands. To allow for commenting on a command line, any text following a (!) on a line is ignored by the script processor. Blank lines and extraneous spacing characters are also ignored.

A script file may contain CLI supervisor commands (Paragraph 3.5) only, or a combination of commands and program parameter responses. Generating script or parameter files is performed off-line using a standard editor system utility.

3.3 PGI FUNCTIONAL MODULE DESCRIPTION

The major function of the PGI module is to handle all information flowing between the operator's terminal or the UUT and the functional level I/O program. While a diagnostic program is executing, that program can call on the supervisor to supply various services. These services provide the program with the required common functions (e.g., memory allocation and mapping, I/O processing, operator terminal interfacing, error message formatting, and system error handling).

Several of the functions the PGI provides are a subset of the VMS system services. For example, the supervisor provides the VMS queue I/O service so that user mode diagnostics may be executed standalone as well as under VMS.

3.3.1 Memory Management and Adapter Services

All memory buffer allocation is performed by the diagnostic supervisor. This ensures system integrity throughout the various operating environments.

All necessary interfacing between the CPU and UUT will be handled by the diagnostic supervisor.

Running standalone, the supervisor provides I/O services similar to those available under VMS. This provides a smaller standalone environment for running user mode diagnostics. Only a small kernel subset of VMS system services is provided.

All functional level diagnostics perform device I/O as specified by the VMS operating system. However, in addition to the normal queue I/O functions, VMS provides special features that diagnostic programs can use if executing as privileged processes. On I/O completion, if requested and privilege permitting, raw status is deposited into a buffer specified by the program. This status contains all device registers and pertinent channel registers. A time stamp is also deposited into the status buffer.

3.3.2 Operator Terminal Services

Since the diagnostic programs do not interface directly with the operator's terminal, the supervisor provides all required operator communication services for the diagnostic program. The program can perform operator dialogue through a supervisor service to allow testing of mechanical devices that require operator interaction.

The terminal drivers within the service eliminate the need for the diagnostic programmer to be aware of the type of terminal currently used by the operator.

The output to the operator, including error reporting, uses formatted ASCII output to simplify the program's message-sending routines. Conversion of binary data to ASCII display is handled by the diagnostic supervisor instead of the programmer. The formatted ASCII output syntax is the same as that used by VMS.

3.3.3 System Error Handling

All system errors are intercepted and reported directly to the operator by the supervisor unless the program explicitly requests notification of exceptions or interrupts.

3.4 SUPERVISOR COMMAND DESCRIPTIONS

The following paragraphs describe the operator command and execution control functions provided by the diagnostic supervisor. Where appropriate, examples of command usage are included.

3.4.1 Command Terms and Symbols

Since the supervisor commands are a subset of the console commands, many of the console command terms and symbols are used in the symbolic supervisor command descriptions. The applicable characters are defined in Table 3-1.

Table 3-1 Term and Symbol Definitions

Term/Symbol	Definition
!	Used to indicate the Exclusive OR operation (i.e., selection of parameters within a command line)
()	Used to indicate that one of the syntactic units of the expression is to be selected
< >	Used to indicate symbolic arguments, or program functions to/from the operator terminal
[]	Used to indicate that part of an expression is optional; e.g., WAIT [<blank> <count>] indicates that the wait command takes an optional <count> argument
<blank>	Represents one or more spaces
<tab>	Represents one or more tabs
<count>	Represents a numeric count
<XYZ - list>	Indicates one or more occurrences from the category indicated by XYZ
<address>	Represents an address argument
<data>	Represents a numeric argument
<qualifier>	Represents a command modifier (switch)
<input prompt>	Represents the console's input prompt string
>>>	Console program input prompt character
DS>	Diagnostic supervisor prompt
<CR>	Represents a console terminal carriage return
<LF>	Represents a console terminal line feed
/	Delimits a command from its qualifiers
,	Used as a separator within a list
:	Used as a separator within a command line.

3.4.2 Command Description Segments

Each supervisor command description is divided into three, four, or five descriptive segments, depending on the particular command. The descriptive segments are:

- a. Syntax: describes the command structure.
- b. Command description: a brief paragraph describing command operation, general restrictions, or available options.
- c. Response: a description of the console program response to the specified command.
- d. Qualifiers: a list of applicable command modifiers.
- e. Options: a list of applicable command options.

The descriptive segments use the terms and symbols defined in Table 3-1. Note that every command (or command line) must be terminated with a <CR>.

3.4.3 Command Abbreviations

Supervisor command words, switches, and arguments may be abbreviated by typing only enough characters to uniquely identify each item. For example, the load command can be specified by L, while the start command requires a minimum entry of ST.

3.4.4 Command Overview

The supervisor operator commands are divided into the three following groups:

- a. Load/test sequence control: provides the operator with the capability of loading and sequencing diagnostic programs.
- b. Execution control: provides the operator with control of the operational characteristics of the diagnostic program and/or supervisor (e.g., looping, error reporting, etc.).
- c. Debug/utility functions: provide the operator with debug and utility functions such as: breakpoints, examine, deposit, etc.

The supervisors also support operator terminal characteristics such as width, fill, etc. In addition, all control functions provided by the console (e.g., Control C) are also supported by the supervisor.

3.5 SEQUENCE CONTROL COMMANDS

The program/test sequence control commands provide the operator with the capability of loading and controlling the sequencing of diagnostic programs, as well as the capability of controlling the

sequence of test execution within a program. The supervisor also provides for the execution of a single subtest, and if the pass count option is used, provides a loop-on-subtest capability.

The submit command allows an entire diagnostic test session to be predefined by the operator. The supervisor is then capable of performing the test session without operator assistance.

Note that the symbolic argument <file spec> as used in the following subsection is defined as:

```
dev unit :[UIC] filename . ext
```

3.5.1 Load Command

Syntax: LOAD <file spec> [/PHYSICAL : <address>] <CR>

The load command causes the specified file to be loaded into memory. The supervisor obtains sufficient information from the program.

After a successful load, the supervisor prints out the following message: Progame-r.p LOADED.

Progame is the program name. This is the internal name which the supervisor extracts from the program header section.

--r.p is the release version number and the DEPO (patch) number of the program.

The optional PHYSICAL switch directs the image loader to attempt to load the program into physically contiguous memory starting at <address>. The <address> argument is normally accepted in hexadecimal format by default.

3.5.2 Start Command

Syntax: START [/SEC : <section name>] -- [/TEST : <first>] [:<last> !/SUBTEST : <number>]] -- [/PASS : <count>] <CR>

The start command causes the program in memory to begin execution. As execution begins, the supervisor enters into a dialogue with the operator to determine the program specific parameters. (e.g., which units to test). The command switches and certain arguments are optional.

The SECTION switch is program specific and not available for use with all programs. When a section is selected, only the tests that it contains will be executed.

The TEST switch is used in two distinctly different ways.

- a. If the <first> and <last> arguments are specified, the supervisor sequentially passes control to tests <first> through <last> inclusively.

- b. If the <first> argument is combined with the SUBTEST switch, program execution begins at the beginning of the <first> test and terminates at the end of SUBTEST <number>.

If the SUBTEST switch is used in conjunction with the PASS switch, the operator is provided with a loop-on-subtest capability. If the optional PASS switch is not specified, a default <count> of one is assumed.

If the TEST switch is not specified, all tests within the program are executed. If only the <first> argument is specified with the TEST switch, the <last> argument is assumed by default to be the highest numbered test within the program.

3.5.3 Restart Command

Syntax: RESTART [/SEC: <section name>] -- [/TEST : <first> [:<last> ! /SUBTEST : <number>]] -- [/PASS : <count>] <CR>

The restart command is similar to the start command; however, the supervisor does not enter into the parameter retrieval dialogue. This command requires that the program P-Tables have been previously setup with a start command. Switch syntax is identical to the start command switches.

3.5.4 Run Command

Syntax: RUN<file spec> [/SEC: <section-name>]! -- [/TEST : <first> [: <last>! -- /SUBTEST : <number>]] [/PASS : <count>]

The run command is equivalent to a load and start command sequence. (Refer to Paragraph 3.5.2 for a description of the optional switches.)

3.5.5 Control Characters and Special Characters

Table 3-2 contains a description of the control and special characters recognized by the supervisor.

Table 3-2 Control/Special Character Descriptions

Character	Description
Control C (^C)	Returns program control to the supervisor which enters a command wait state. The operator may then issue any valid supervisor command.
Control O (^O)	Suppresses or enables (on a toggle basis) console terminal output. Console terminal output is always enabled at the next console terminal supervisor input prompt. However, the supervisor will override ^O and reinstate an active output status to the operator terminal when it is servicing system errors, CLI prompts, or forced messages.
Control U (^U)	^U typed before a line terminator causes the deletion of all characters entered since the last line termination. The console echoes: ^U/<CR><LF>
Rubout	Typing rubout deletes the last character typed on the input line. Only characters entered since the last line terminator can be rubbed out. Several characters can be deleted in sequence by typing successive rubouts. The first rubout echoes as a backslash (\) followed by the character which has been deleted. Subsequent rubouts cause only the deleted character to be echoed. The next character typed that is not a rubout causes another (\) to be printed, followed by the new character to be echoed.
Carriage Return (CR)	Terminates a command line.

3.5.6 Continue Command**Syntax:** CONTINUE <CR>

The continue command causes program execution to resume at the point at which the program was suspended. This command is used to proceed from a breakpoint, error halt, or Control C situation.

3.5.7 Summary Command**Syntax:** SUMMARY <CR>

The summary command causes the execution of the program's summary report code section which prints statistical reports.

3.5.8 Abort Command

Syntax: ABORT <CR>

The abort command executes the program's cleanup code and returns control to the supervisor, which enters a command wait state. At this point the operator may issue any command except restart or continue.

3.5.9 Submit Command

Syntax: SUBMIT <file spec> [/LOG : ON ! OFF] [/CONSOLE : ON! OFF] <CR>

The submit command causes the supervisor to read a script file from any file-oriented device. The supervisor performs the functions outlined in the script file and then returns control to the operator at the console.

The script file may contain any valid operator commands, including a submit command. However, a submit command within a script file is considered a terminal command (i.e., the supervisor will close the current script and log files and open new ones as specified by the current command).

If the LOG switch is specified as ON, a transcript of the indirect terminal dialogue is maintained in a file of the same filename as the script file with an extension of .LOG on the device where the script file is located. The default for this switch is OFF.

If the CONSOLE switch is specified as ON, the terminal dialogue generated by the script file is printed on the operator's terminal. The default for this switch is ON.

3.6 EXECUTION CONTROL COMMANDS

This group of commands allows the operator to statically or dynamically alter the operational characteristics of the diagnostic program and/or the supervisor. These functions are implemented by flags that reside in both the supervisor and the program. The event flags are located within the diagnostic program and are supported by VMS and the supervisor.

These commands are used to control the printing of error messages, ringing the bell, halting and looping of the program, etc. Flags are provided that indicate to the supervisor which type of dialogue characteristics are desired by the operator. The operator also has access to a subset of the event flags that are available to the program.

3.6.1 Set Control Flag Command

Syntax: SET [FLAGS] <argument list> <CR>

This command sets the execution control flags specified by <argument list>; no other flags are affected. <argument list> is a string of flag mnemonics separated by commas. The applicable flags are described in Table 3-3.

Table 3-3 Control Flag Descriptions

Flag	Description
HALT	Halt on error detection. When the program detects a failure, with this flag set, the supervisor enters a command wait state after all error messages associated with the failure have been output. The operator may then continue, restart, or abort the program. This flag takes precedence over the LOOP flag.
LOOP	<p>Loop on error. When set, this flag causes the program to enter a predetermined scope loop on a test or subtest that detects a failure.</p> <p>Looping will continue until the operator returns to the supervisor by using ^C. The operator may then continue, clear the flag and continue, restart, or abort the program.</p>
BELL	Bell on error. When set, this flag will cause the supervisor to output a bell to the operator whenever the program detects a failure.
IE1	Inhibit error messages at level 1. When set, this flag suppresses all error messages except those that are forced by the program or supervisor.
IE2	Inhibit error messages at level 2. When set, this flag suppresses basic and extended information concerning the failure. Only the header information message (the first three lines) is output for each failure.
IE3	Inhibit error messages at level 3. When set, this flag suppresses extended information concerning the failure. The header and basic information messages are output for each failure.
IES	Inhibit summary report. When set, this flag suppresses statistical report messages.
QUICK	Quick verify. When set, this flag indicates to the program that the operator desires a quick verify mode of operation.

Table 3-3 Control Flag Descriptions (Cont)

Flag	Description
SPOOL	List error messages on line printer. When set, this flag causes the supervisor to direct all program messages to the line printer. In the VMS environment, the messages are not actually printed but entered into a file on disk (not yet implemented).
TRACE	Report the execution of each test. When set, this flag causes the supervisor to report the execution of each individual test within the program as the supervisor dispatches to that test.
LOCK	Lock in physical memory. When set, this flag disables the program relocation function. Self-relocating programs are then locked into their current physical memory space.
OPERATOR	Operator present. When set, this flag indicates to the supervisor that operator interaction is possible. When cleared, the supervisor takes appropriate actions to ensure that the test session bypasses any tests that require manual intervention.
PROMPT	Display long dialogue. When set, this flag indicates to the supervisor that the operator wants to see the limits and defaults for all questions printed by the program.
ALL	All flags in this list.

3.6.2 Clear Control Flag Command

Syntax: CLEAR [FLAGS] <argument list> <CR>

The clear command clears the flags specified by <argument list>; no other flags are affected. The <argument list> is a string of flag mnemonics separated by commas. The supported arguments are described in Table 3-3.

3.6.3 Set Control Flag Default Command

Syntax: SET FLAGS DEFAULT <CR>

This command returns all flags to their initial default status. The default flag settings are OPERATOR and PROMPT.

3.6.4 Show Control Flags Command

Syntax: SHOW FLAGS <CR>

This command causes the display of all execution control flags and their current status. The flags are displayed as two mnemonic lists: one for set flags, one for clear flags.

3.6.5 Set Event Flags Command

Syntax: SET EVENT [FLAGS] <argument list> ! ALL <CR>

This command sets those event flags specified by <argument list>; no other event flags are affected. The <argument list> is a string of flag numbers in the range 1--23, separated by commas. The optional ALL may be specified instead of <argument list>.

Event related services are provided by the supervisor to provide intraprocess synchronization and signaling by means of event flags. Event flags are located in clusters of 32 flags each.

The supervisor provides two event flag clusters. Event flags are specified by the numbers 0--63. However, flags 24--31 are restricted for use by VMS. The operator has the capability to interactively set and clear flags 1--23.

Note that numbers 32--63 are for program use. Number 0 is used by the supervisor.

3.6.6 Clear Event Flags Command

Syntax: CLEAR EVENT [FLAGS] <argument list> ! ALL <CR>

This command clears those event flags specified by <argument list>; no other event flags are affected. The optional ALL may be specified instead of <argument list>.

3.6.7 Show Event Flags Command

Syntax: SHOW EVENT [FLAGS] <CR>

This command causes the display of a list of the event flags currently set.

3.7 DEBUG AND UTILITY COMMANDS

This group of commands provides the operator with the ability to alter diagnostic program code. The supervisor allows up to 15 simultaneous breakpoints within the program. The operator can also examine and/or modify the program image in memory. Optionally, a modified image can be written to a load device so that patching need occur only once.

Another feature allows the operator to unconditionally list any or all of the program error messages.

3.7.1 Set Base Command

Syntax: SET BASE <address> <CR>

This command loads the address specified into a software register. This number is then used as a base to which the address specified in the set breakpoint, clear breakpoint, examine, and deposit commands is added. The set base command is useful when referencing code in the diagnostic program listings. The base should be set to the base address (see the program link map) of the program section referenced. Then the PC numbers provided in the listings can be used directly in referencing locations in the program sections.

NOTE

Virtual address = physical address
(normally) when memory management is
turned off.

3.7.2 Set Breakpoint Command

Syntax: SET BREAKPOINT <address> <CR>

This command causes control to pass to the supervisor when program execution encounters the <address> previously specified by this command. A maximum of 15 simultaneous breakpoints can be set within the diagnostic program.

3.7.3 Clear Breakpoint Command

Syntax: CLEAR BREAKPOINT <address> ! ALL <CR>

This command clears the previously set breakpoint at the memory location specified by <address>. If no breakpoint existed at the specified address, no error message is given. An optional argument of all clears all previously defined breakpoints.

3.7.4 Show Breakpoints Command

Syntax: SHOW BREAKPOINTS <CR>

This command displays all currently defined breakpoints.

3.7.5 Set Default Command

Syntax: SET DEFAULT <argument list> <CR>

This command causes setting of default qualifiers for the examine and deposit commands. The <argument list> argument consists of a data length default and/or radix default qualifiers. If both qualifiers are present, they are separated by a comma. If only one default qualifier is specified, the other one is not affected. Default defaults are HEX and LONG. Default qualifiers are:

Data Length: Byte, Word, Long
Radix: Hexadecimal, Decimal, Octal

3.7.6 Examine Command

Syntax: EXAMINE [<qualifiers>] [<address>] <CR>

The examine command displays the contents of memory in the format described by the qualifiers. If no qualifiers are specified, the default qualifiers set by a previous default command are implemented. The applicable qualifiers are described in Table 3-4.

Table 3-4 Qualifier Descriptions

Qualifier	Description
/B	Address points to a byte
/W	Address points to a word
/L	Address points to a longword
/X	Display in hexadecimal radix
/D	Display in decimal radix
/O	Display in octal radix
/A	Display in ASCII bytes

When specified, the <address> argument is accepted in hexadecimal format unless some other radix has been set with the set default command. Optionally, <address> may be specified by immediately preceding the address argument with %D OR %O, respectively. <Address> may also be one of the following: R0--R11, AP, FP, SP, PC, PSL.

3.7.7 Deposit Command

Syntax: DEPOSIT [<qualifiers>] <address> <data> <CR>

The command accepts data and writes it into the memory location specified by <address> in the format described by the qualifiers. If no qualifiers are specified, the default qualifiers are implemented. The applicable qualifiers are identical to those of the examine command and described in Table 3-4.

The <address> argument is accepted in hexadecimal format unless some other radix has been set with the set default command. Optionally, <address> may be specified as decimal or octal by immediately preceding <address> with %D or %O, respectively.

BLANK

CHAPTER 4 MICRODIAGNOSTIC DESCRIPTION

4.1 MICRODIAGNOSTIC PROGRAM OVERVIEW

The microdiagnostic programs provide module isolation for logic failures within the CPU, floating-point, and MDS memory controllers. All detected failures result in an error printout indicating the module, or smallest set of modules, to which the microdiagnostics can isolate the failure.

The microdiagnostic package consists of two major test divisions: console adapter and hardcore, and microtests. Each test division is controlled by an associated monitor that provides non-diagnostic services to that division.

- a. Hardcore Monitor -- Console Adapter and Hardcore Program
- b. Microtest Monitor -- Microtest Program

Both test division monitors are serviced by the console-resident microdiagnostic monitor. In addition to loading the hardcore and microtest monitors, the microdiagnostic monitor allows the operator test selection and execution options (Paragraph 4.6). In order to reduce the address space required to execute the hardcore and microtest programs, the common code of both programs has been incorporated into the microdiagnostic monitor. That code, which is unique to either the hardcore tests or microtests, has been incorporated into the associated monitors.

The microdiagnostics reside on diskettes for the floppy drive. The basic test sequence is: 1) hardcore tests, 2) microtests. The hardcore tests verify the operation of the minimum logic required to reliably execute the microtests. The minimum logic consists of the basic hardware elements required for data transfer and error reporting.

The code, data, and structure required by the microdiagnostics prohibit them from being resident in the LSI-11 address space at any one time. The hardcore tests are executed out of a small buffer area in the LSI-11 memory. The microtests are executed out of the WCS of the VAX-11/780 CPU.

4.2 BASIC PROGRAM EXECUTION

With the console program resident (in LSI-11 memory), the operator can execute the entire microdiagnostic package by issuing the test command. The console program overlays itself with the microdiagnostic monitor from the console floppy. (However, the floppy and terminal software drivers are not overlaid since they provide utility service to each of the monitors.)

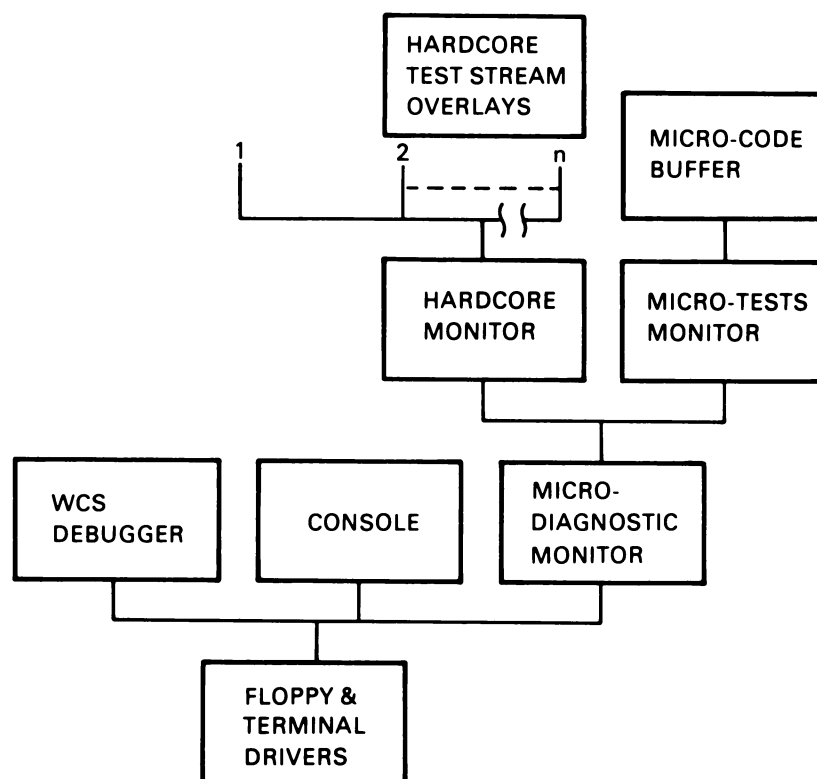
In turn, the microdiagnostic monitor transfers the hardcore monitor into the LSI-11 memory from the floppy. The hardcore tests are then executed sequentially out of the buffer in the LSI-11 memory. On completion of the hardcore tests, the hardcore monitor notifies the microdiagnostic monitor. The microdiagnostic

monitor, in turn, transfers the microtest monitor into the LSI-11 memory (from floppy). The microtest monitor then executes the microtests out of the WCS in approximately 1K microword overlays. On completion of the microtests, control is returned to the console program.

Figure 4-1 illustrates program residency in the LSI-11 memory. Note that those items on a horizontal line are exclusive in memory; e.g., the console program or the microdiagnostic monitor may be resident, but not both. As previously mentioned, the floppy and terminal drivers (and software bootstrap) are always resident.

4.3 BASIC TEST STRATEGY

The basic test strategy is to transfer data from a test source and load it into the logic element under test. The next step is to retrieve the data from that element and compare it with the original data loaded. Depending on the test requirements, logic element structure, and functional location, the retrieved data may or may not have a true compare. In either case, the fail/no fail decision is based on the expected results. In some tests, the same logic is tested using an array of data patterns.

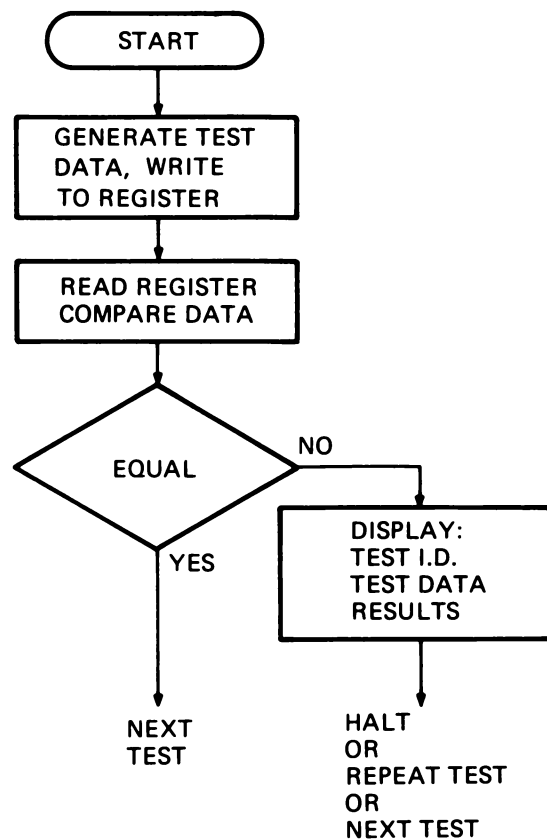


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Figure 4-1 LSI-11 Memory Program Residency

It is essential to the test strategy that the basic load and error reporting paths are initially tested for reliable operation. In an error-free situation, the microdiagnostic can notify the user when a test is completed. In the case of error detection, the microdiagnostic can identify for the user: the failed module and test, the data pattern used, and the expected test result.

A simplified test procedure is illustrated in Figure 4-2. Note that a true compare is not necessarily the expected result.



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Figure 4-2 Simplified Microdiagnostic Test Procedure

4.4 **HARDCORE TEST DESCRIPTION**

The hardcore tests are the initial set of microdiagnostic tests executed. Paragraph 4.4.1 describes the hardcore test structure.

The hardcore tests initially check the control and data registers of the Console Interface Board (CIB). This ensures test access to the VAX ID Bus. After the CIB tests, the clock board is tested. The clock is turned on and off, single-stepped, and certain clock function status is retrieved over the Visibility Bus (V Bus).

The next element tested is the microsequencer. For example, data is transferred onto the microstack and then retrieved. An address is placed on the microstack. The maintenance return feature is then used to pop the address off the microstack and load it into the micro PC. This allows the microaddress paths to be tested in small segments.

As shown in Figure 4-3, the remainder of the hardcore test sequence tests WCS, PROM Control Store (PCS), and basic elements of the data path. Generally, these are address integrity and parity checking tests. The WCS is tested by writing a variety of address and data patterns to it, and checking for good parity, or forced bad parity.

The basic elements of the data path are tested by writing data to certain registers, reading that data back, and comparing the results. The data path is tested for its ability to transmit and retain expected data. The basic capabilities of the Arithmetic Logic Unit (ALU) to transfer and compare data are tested. The scratch pads are also tested for retaining data; the scratch pads are used to hold error data in the case of error detection.

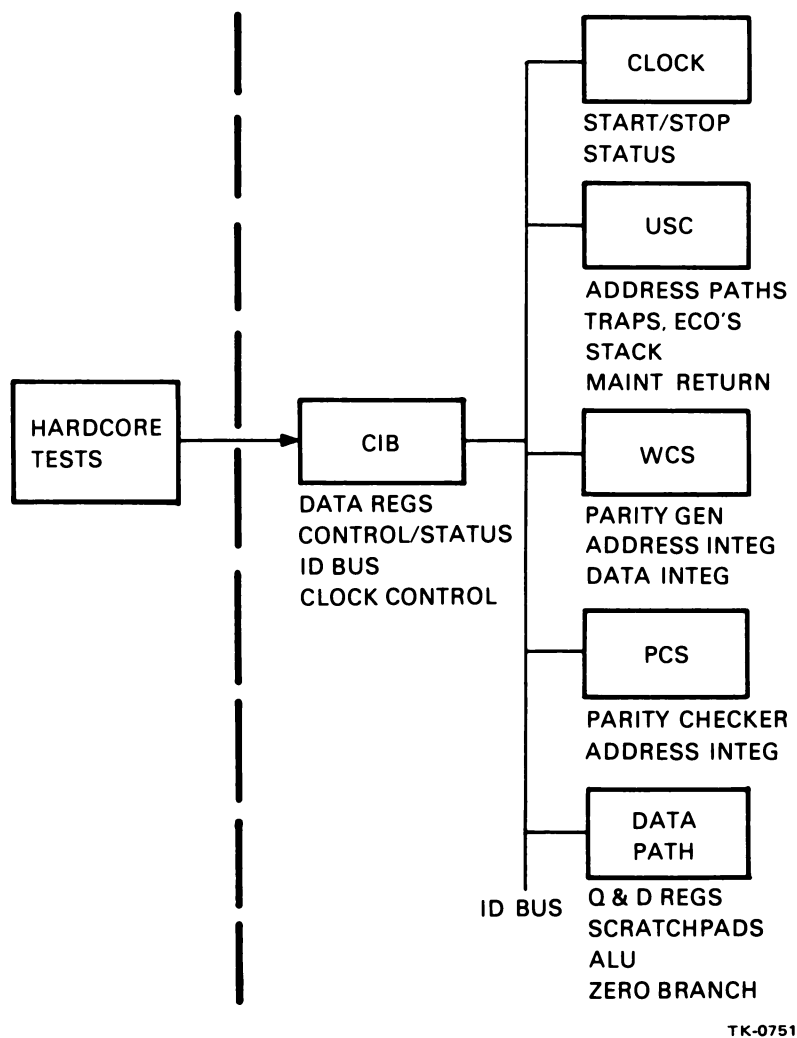


Figure 4-3 Hardcore Test Sequence

4.4.1 Hardcore Test Structure

Because of the limited LSI-11 memory address space, the hardcore tests are sequentially loaded from the floppy and executed out of a 1.5K byte buffer in the LSI-11 memory. The hardcore tests are implemented using special pseudo instructions. The pseudo instructions are actually functional statements, where each statement produces a table of parameters that resemble op codes and operand addresses.

The hardcore monitor contains a software PC which, in effect, is a pointer into the tables. Based on the content of the op codes and operands, the monitor calls subroutines that are written in PDP-11 code to perform the operation required by a specific test. Implementing test code in this manner allows a large test functionality to reside in a small address space.

4.4.2 Pseudo Instruction Description

The following paragraphs describe the hardcore test pseudo instructions and their associated statement formats. Table 4-1 defines the symbols and abbreviations used in describing the statement formats.

Table 4-1 Instruction Symbol/Abbreviation Definitions

Item	Definition
< >	Used to denote a category name or argument within a functional statement, e.g., <SCR ADDRESS> represents a valid source address.
[]	Used to indicate that part of a functional statement that is optional, e.g., [<WCS ADDRESS INDEX>], represents an address index value that may or may not be specified depending on the functional statement.
,	Used to separate category names or arguments within a functional statement.
SCR	Abbreviation for source.
DST	Abbreviation for destination.
I,J,K	Legal index names.

Each pseudo instruction description is divided into two descriptive segments. The format segment describes the statement format using the symbols defined in Table 4-1. The instruction description is a brief paragraph describing general command operation and the available options. Each instruction description is preceded by the instruction mnemonic in boldface type.

BLKMIC

BLKMIC <SCR ADDRESS>, <SCR INDEX>, <WCS ADDRESS>,
<WORD COUNT>, [<WCS ADDRESS INDEX>]

Move the <WORD COUNT> number of 96-bit microwords from the <SCR ADDRESS>, indexed by <SCR INDEX>, to the WCS starting at <WCS ADDRESS>, indexed by <WCS ADDRESS INDEX>. If an <SCR INDEX> is specified, the <SCR ADDRESS> is indexed by six PDP-11 words (i.e., 96 bits).

If the <WCS ADDRESS> starts with an alpha character, the <WCS ADDRESS> is used as a pointer to a table in the test data area of the test. Otherwise, it is used as a physical WCS address.

For example, if the current value of the index is 2, 14_8 (<SCR INDEX> * 6) would be added to the <SCR ADDRESS> to find the first 96-bit microword to load into the WCS.

CHKPNT

CHKPNT [<PASS ADDRESS>], [<FAIL ADDRESS>]

If the error flag, set during a compare instruction (see CMPXXX instructions), is zero, go to the <PASS ADDRESS>. If the error flag is not zero, go to the <FAIL ADDRESS>. If neither a pass nor a fail address is specified, go to the next instruction in line.

The address of the next instruction is typed. These addresses appear on the typed line named TRACE (Figure 4-10).

CLOCK

CLOCK <TIMES>

Step the system clock <TIMES> number of single time states. If <TIMES> is an integral number of four, single bus cycles are executed for each four <TIMES>.

CMPCA

CMPCA [<MODE>], <REGISTER>, <DST ADDRESS>, [<DST ADDRESS INDEX>]

Compare the contents of the console register specified by <REGISTER> with the contents of the location specified by <DST ADDRESS>, indexed by <DST ADDRESS INDEX>. The <MODE> argument is generally EQUAL. If left blank, the default for <MODE> is EQUAL.

If the comparison is false, set the error flag. If the <MODE> argument is not specified, it defaults to EQUAL.

If the <REGISTER> argument is specified as IDREGLO or IDREGHI, the register used in the comparison is the ID Bus register that was read in the most recent READID instruction.

CMPCAD

CMPCAD [<MODE>], <REGISTER>, <DST ADDRESS>, [<DST ADDRESS INDEX>]

Compare the contents of the console registers specified by <REGISTER> and <REGISTER>+2 with the contents of the location specified by <DST ADDRESS> and <DST ADDRESS>+2, indexed by <DST ADDRESS INDEX>.

If the comparison is false, set the error flag. If the <MODE> argument is not specified, it defaults to EQUAL.

If the <REGISTER> argument is specified as IDREGLO or IDREGHI, the register used in the comparison is the ID Bus register that was read in the most recent READID instruction.

CMPCAM

CMPCAM [<MODE>], <REGISTER>, <MASK ADDRESS>, [<MASK ADDRESS INDEX>], <DST ADDRESS>, [<DST ADDRESS INDEX>]

Take the content of the console register specified by <REGISTER>, mask it with the content of the <MASK ADDRESS>, indexed by <MASK ADDRESS INDEX>, and compare it with the content of <DST ADDRESS>, indexed by <DST ADDRESS INDEX>.

If the comparison is false, set the error flag. If the <MODE> argument is not specified, it defaults to EQUAL.

If the <REGISTER> argument is specified as IDREGLO or IDREGHI, the register used in the comparison is the ID Bus register that was read in the most recent READIN instruction.

The mask is performed by taking the content of <MASK ADDRESS>, indexed by <MASK ADDRESS INDEX>, complementing it, and bit-clearing the contents of <REGISTER> with it.

CMPCMD

CMPCMD [<MODE>], <REGISTER>, <MASK ADDRESS>, [<MASK ADDRESS INDEX>], <DST ADDRESS>, [<DST ADDRESS INDEX>]

Take the content of the console registers specified by <REGISTER> and <REGISTER>+2, mask it with the contents of <MASK ADDRESS> and <MASK ADDRESS>+2, indexed by <MASK ADDRESS INDEX>, and compare it with the contents of <DST ADDRESS> and <DST ADDRESS>+2, indexed by <DST ADDRESS INDEX>.

If the <MODE> argument is false, set the error flag. If the <MODE> argument is not specified, it defaults to EQUAL.

If the <REGISTER> argument is specified as IDREGLO or IDREGHI, the register used in the comparison is the ID Bus register that was read in the most recent READIN instruction.

The mask is performed by taking the content of <MASK ADDRESS> and <MASK ADDRESS>+2, indexed by <MASK ADDRESS INDEX>, complementing it, and bit-clearing the contents of <REGISTER> and <REGISTER>+2.

CMPPCSV

CMPPCSV <DST ADDRESS>, [<DST ADDRESS INDEX>]

Compare the content of the PC save register with the content of the location specified by <DST ADDRESS>, indexed by <DST ADDRESS INDEX>. If the contents are not equal, set the error flag.

ENDLOOP

ENDLOOP <INDEX NAME>

Add the increment value of <INDEX NAME> (see loop instruction) to the current value of the index specified by <INDEX NAME>. Compare the current value with the last value (specified in the loop instruction). If the current value is less than or equal to the last value, go to the instruction following the associated (I, J, or K) loop instruction. Otherwise, go to the next sequential instruction.

ERRLOOP

ERRLOOP

Save the address of the next instruction. If an error is detected, and the loop or error flag is set (Paragraph 4.6), execution is restarted at this saved address after the IFERROR instruction is executed (Figure 4-11).

FETCH

FETCH <WCS ADDRESS>, [<WCS ADDRESS INDEX>], [<WCS ROM NOP>]

If <WCS ADDRESS> is a numeric string, execute a maintenance return to the location specified by <WCS ADDRESS>, indexed by <WCS ADDRESS INDEX>. If <WCS ADDRESS> is an alphanumeric string, execute a maintenance return to the location specified by the content of <WCS ADDRESS>, indexed by <WCS ADDRESS INDEX>. If <ROM NOP> is specified, clear bit 7 of the Machine Control Register (MCR) during the maintenance return.

FLTONE

FLTONE <DST ADDRESS>, <INDEX NAME>

Generate a 32-bit word of all zeros. Insert a logic one in the bit position specified by the current value minus one of <INDEX NAME>, and load this word into the location specified by <DST ADDRESS> and <DST ADDRESS>+2.

FLTZRO

FLTZRO <DST ADDRESS>, <INDEX NAME>

Generate a 32-bit word of all logic ones. Insert a zero in the bit position specified by the current value minus one of <INDEX NAME>, and load this word into the location specified by <DST ADDRESS> and <DST ADDRESS>+2.

IFERROR

IFERROR [<MESSAGE NUMBER>], [<FAIL ADDRESS>]

If the error flag is nonzero, type the PC of this instruction, the test number, subtest number, and the good and bad data. Then, go to <FAIL ADDRESS> if the HALTD flag is not set (Paragraph 4.6).

If the error flag is zero, or the <FAIL ADDRESS> is not specified, go to the next instruction.

INITIALIZE

INITIALIZE

Set and clear the CPU initialize bit in the MCR, clear the single time state bit, set the single bus cycle bit, set the ROM NOP bit, and set the proceed bit in the MCR.

KMXGEN

KMXGEN <SRC ADDRESS>, <INDEX NAME>

Generate the KMUX address specified by the current value minus one of <INDEX NAME> and load it into the KMUX field of the microinstruction specified by <SRC ADDRESS>. <SRC ADDRESS> points to a six word table in the test data section of the test that contains the microinstruction.

LDIDREG

LDIDREG <REGISTER>, <SRC ADDRESS>, [<SRC ADDRESS INDEX>]

Load the ID Bus register specified by <REGISTER> with the contents of the locations specified by <SCR ADDRESS> and <SCR ADDRESS>+2, indexed by <SRC ADDRESS INDEX>.

If <REGISTER> is the microstack, microbreak, or WCS address, the content of <SCR ADDRESS> is taken to be 16 bits. Otherwise, it is taken to be 32 bits.

LOADCA

LOADCA <REGISTER>, <SRC ADDRESS>, [<SRC ADDRESS INDEX>]

Load the console register specified by <REGISTER> with the content of the location specified by <SRC ADDRESS>, indexed by <SRC ADDRESS INDEX>. This instruction loads 16 bits of data.

LOOP

LOOP <INDEX NAME>, <START>, <END>, [<SIZE DEPENDENT>]

Initialize the loop parameter specified by <INDEX NAME> to the value specified by <START>. Save the value specified by <END> for the ENDLOOP instruction. Calculate and save the increment value for the ENDLOOP instruction with the following algorithm:

If <START> is less than or equal to
<END>, set the increment value to +1;
otherwise, set it to -1.

If <END> is an <INDEX NAME>, save the current value of that index name as the <END> value of this index name.

If <SIZE DEPENDENT> is specified, and there is only one WCS module on the system, divide the larger of <START> and <END> by two. Otherwise, leave them unchanged.

NOTE

The tests are written for two WCS modules. This argument allows the loop parameters to be modified at run time if the system only has one module.

MASK

MASK <DST ADDRESS>, <MASK ADDRESS>

Take the content of location <MASK ADDRESS>, complement it, and bit-clear the content of location <DST ADDRESS> with it.

MOVE

MOVE <SRC ADDRESS>, [<SRC ADDRESS INDEX>], <DST ADDRESS>

Move the content of <SRC ADDRESS INDEX> (indexed by <SRC ADDRESS INDEX>) to the location specified by <DST ADDRESS>.

NEWTST

NEWTST <TEST NAME>, [<TEST DESCRIPTION>], [<LOGIC
DESCRIPTION>], [<ERROR DESCRIPTION>], [<SYNC POINT
DESCRIPTION>]

This instruction creates a test header document for the specified arguments. It clears the error flag and saves the PC of the next instruction for looping on test.

READID

READID <REGISTER>

Read the ID Bus register specified by <REGISTER> and load the content into locations IDREGLO and IDREGHI.

RESET

RESET

Execute an LSI-11 reset instruction.

REPORT

REPORT <MODULE NAME STRING>

Type out the module numbers of the modules specified by <MODULE NAME STRING>. If the HALTI flag is set, return to the microdiagnostic monitor.

SETPSW

SETPSW <DATA>

Load the LSI processor status word with the value specified by <DATA>.

SETVEC

SETVEC <VECTOR ADDRESS>

Set the LSI-11 address specified by <VECTOR ADDRESS> to the expected trap routine.

SKIP

SKIP [<DST ADDRESS>]

Go to the <DST ADDRESS>. If <DST ADDRESS> is not specified, go to the next test. If <DST ADDRESS> starts with the alpha character S, go to the next subtest.

SUBTEST

SUBTEST

Increment the subtest counter.

TSTVB

TSTVB <SRC TABLE ADDRESS>, [<SRC TABLE ADDRESS INDEX>]

Load and read the V Bus. Compare the contents of the data at <SRC TABLE ADDRESS>, indexed by <SRC TABLE ADDRESS INDEX>, with the V Bus data just read. The <SRC TABLE> has the following format:

```
1$: .WORD    <NUMBER OF BITS TO CHECK>
    VBUSG    <CHANNEL NUMBER>, <BIT NUMBER>, <EXPECTED BIT
              VALUE>
.
2$: .WORD    <NUMBER OF BITS TO CHECK>
    VBUSG    <CHANNEL NUMBER>, <BIT NUMBER>, <EXPECTED BIT
              VALUE>
.
.
.
```

VBUSG is a MACRO name that encodes the three arguments into one 16-bit word as follows:

```
BITS <07:00> = <CHANNEL NUMBER>
BITS <14:08> = <BIT NUMBER>
BIT <15> = <EXPECTED BIT VALUE>
```

The following is an example of the <SRC TABLE ADDRESS INDEX>:

```
TSTVB 1$,I
If the current value of the <SRC TABLE ADDRESS INDEX> is 2,
and the <SRC TABLE> looks like the preceding table, the
physical <SRC TABLE ADDRESS> would be 2$.
```

TYPESIZE

TYPESIZE

Use the content of location BADDATA, which contains the value of the WCS data register when it was read, to determine the WCS module configuration, and type a message and the number of WCS modules that will be tested. If any of the following conditions exist, the test stream is aborted and the NER (No Error Report) flag is set.

- a. WCS module count is zero
- b. bits 3--0 are nonzero
- c. fifth K of WCS is not present

These conditions mean that the WCS is either configured incorrectly or the WCS data register cannot be read correctly.

4.5 MICROTEST DESCRIPTION

On completion of the hardcore tests, the microdiagnostic monitor overlays the hardcore monitor with the microtest monitor. Microtest sequencing and execution are then controlled by the microtest monitor.

The microtest monitor begins to load the microtests from the floppy into the same buffer area used by the hardcore tests. However, in the case of microtests, this area is strictly a buffer. Since the microtests are implemented in system microcode, the tests are transferred from the buffer and loaded into and executed out of the WCS.

The monitor references a table that contains the WCS addresses of the first instruction of every test in the overlay (section) that was just loaded in order to locate the address of the first test (first entry in the table). The address is loaded onto the microstack. A maintenance return is performed, popping the address from the microstack into the micro PC and initiating execution of the first test. At the end of each test, the microtest monitor is interrupted. This allows the monitor to check that the microtests are being executed in the correct order.

The monitor then initiates the next test with another maintenance return. This sequence continues until the original 1K microword overlay has been executed. At this point, the microtest monitor loads another 1K microword overlay into WCS.

Because of the microtest package size, more than one diskette is required for storage. When the monitor executes the last test on a diskette, it determines whether it is the last test of the entire package. In the case where it is the last test, the monitor prints out a message to the operator with instructions to load the next sequential diskette and enter a command to continue microtest execution (Paragraph 4.8).

4.5.1 Microtest Structure

The initial microtests complete the data path testing started by the hardcore tests. The microtests then begin to test the Translation Buffer (TB) and cache without using memory. The tests check the TB and cache for their ability to retain correct address and data information, and to check parity correctly.

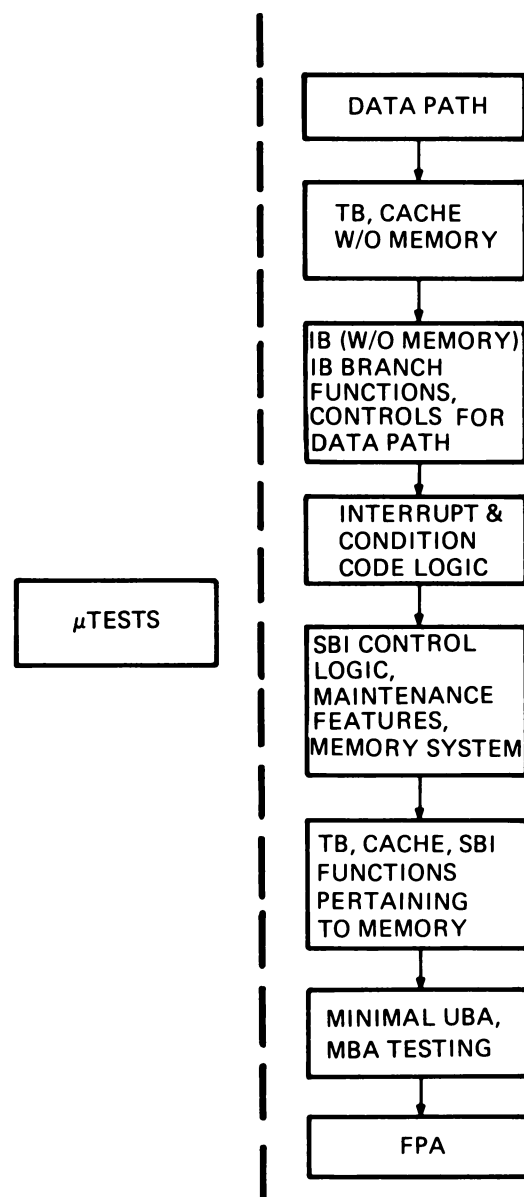
The Instruction Buffer (IB) tests are then executed, again without using memory. The IB test data is loaded into cache. The microtests cause instruction test patterns to be retrieved from cache, and check the IB branching functions and controls for the data path.

The interrupt and condition code logic is checked in a similar manner (i.e., test data loaded into and subsequently retrieved from cache.)

The next test segment covers the SBI control logic and its maintenance functions, and the memory system. After performing these tests, the microtests go back and test those functions of the TB, cache, and SBI subsystem that depend on retrieving data from memory (e.g., cache, SBI faults, etc.). A minimal amount of testing is performed on the Unibus and Massbus adapters. These tests force selected errors on the SBI and determine the adapters' capability to detect and react to the forced errors correctly.

The floating-point accelerator is tested last.

Figure 4-4 shows the microtest sequence.



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Figure 4-4 Microtest Structure

On completion of the microtests, control is returned through the microdiagnostic monitor to the console program. The console reboots, sends the relevant bootstrap header information to the console terminal, and prompts for operator input.

4.6 MICRODIAGNOSTIC MONITOR CONTROLS

The following paragraphs describe the operator command execution control functions provided by the microdiagnostic monitor. Where appropriate, examples of command and program control flag usage are included. Also included is a description of microdiagnostic related error messages.

The majority of the commands available in the microdiagnostic monitor are not used in the normal course of execution. Normally the operator enters the test command and executes the entire microdiagnostic package. The command mode is usually used following error detection. Following the error message printout, testing stops and control is returned to the monitor command mode. At this point, the operator executes those microdiagnostic commands he decides would be most helpful.

Symbols used in the command syntax are the comma and < >. The comma is used to separate items within a list. < > denotes an argument, that is, either an address, pass count value, or a V Bus channel. Note that every command (or command line) must be terminated with a carriage return (CR).

Control C (^C) is the user interrupt control character. If Control C is entered during test execution, the current test will complete, further testing is suspended, and control is returned to the monitor command mode. If Control C is entered while a test is looping on an error, the loop will be suspended and control returned to the command mode. Any command may be aborted if a Control C is entered in that command line.

Table 4-2 describes the monitor commands. Note that although all commands, keywords, qualifiers, and flags are spelled out, they can be abbreviated to the first two characters. The only exceptions are the halt on error detection and halt on error isolation flags, which must be typed HD and HI, respectively.

Table 4-2 Microdiagnostic Command/Flag Descriptions

Command/Flag	Description
DIAGNOSE	<p>Initializes the program control flags, and starts microdiagnostic execution at test number one.</p> <p>Valid qualifiers are:</p> <p>/TEST: <NUMBER> -- Dispatch to the test number specified (do not execute any prior tests), and loop on the test indefinitely.</p> <p>/SECTION: <NUMBER> -- Dispatch to the section number specified (do not execute any prior sections), and loop on the section indefinitely.</p> <p>/PASS: <NUMBER> -- Execute the micro-diagnostics and the specified number of passes before returning to the console. If the number is -1, execute the micro-diagnostics indefinitely.</p> <p>/CONTINUE -- Used with the /TEST or /SECT switch to automatically continue after the specified test or section has been reached.</p> <p>/TEST: <N> <M> -- Dispatch to test <N>, execute tests <N> through <M> (inclusive), and return to command mode.</p> <p>/SECT: <N> <M> -- Dispatch to section <N>, execute sections <N> through <M> (inclusive), and return to command mode.</p>

NOTE

In the preceding variations of the /TEST and /SECTION qualifiers, the value of <N> must be less than or equal to <M>. If <M> is less than <N>, testing will start at <N> and continue to the end.

/TEST and /SECT cannot be specified simultaneously.

Examples

DIAG/TEST:2F
Dispatch to test number 2F and execute it indefinitely.

Table 4-2 Microdiagnostic Command/Flag Descriptions (Cont)

Command/Flag	Description
	<p>DIAG/SECT:B Dispatch to section number B and execute it indefinitely.</p> <p>DIAG/PASS:--1 Execute all of the microdiagnostics indefinitely.</p> <p>DIAG/TEST:2F/CONT Dispatch to test 2F and start execution of the remaining tests.</p>
CONTINUE	Continues microdiagnostic execution without changing the program control flags.
Set and Clear Flags	
SET/CLEAR FLAG HD	Sets (or clears) the halt on error detection flag.
SET/CLEAR FLAG HI	Sets (or clears) the halt on error isolation flag.
SET/CLEAR FLAG LOOP	Sets (or clears) the loop on error flag.
SET/CLEAR FLAG NER	Sets (or clears) the no error report flag.
SET/CLEAR FLAG BELL	Sets (or clears) the bell on error flag.
SET/CLEAR FLAG ERABT	Sets (or clears) the error abort flag.
CLEAR FLAG LS	Clears the loop on special section flag. (Note that this flag cannot be set.)
CLEAR LT FLAG	Clears the loop on special test flag. (Note that this flag cannot be set.)
SET/CLEAR FLAG ALL	Sets (or clears) all of the previous flags.
SET/CLEAR SOMM	Sets (or clears) the stop on micromatch bit.
SET/CLEAR SOMM:<ADDRESS>	Loads address into the CPU microsync register, and sets (or clears) the stop on micromatch bit.

Table 4-2 Microdiagnostic Command/Flag Descriptions (Cont)

Command/Flag	Description
SET/CLEAR FPA:<ADDRESS>	Loads <ADDRESS> into the FPA microsync register.
SET STEP STATE	Sets the CPU clock to single time state.
SET STEP BUS	Sets the CPU clock to single bus cycle.
	Both the SET STEP STATE and SET STEP BUS commands cause the monitor to enter step mode. Step mode types the current clock state or the UPC value, and waits for terminal input. If a space is typed, the clock is triggered and the current UPC value is typed out. If any other character is entered, step mode is exited.
SET STEP INSTRUCTION	Sets the software single instruction flag and returns to the monitor. When the hardcore tests are invoked, the current value of the Test PC (TPC) is typed. The monitor waits for terminal input. If a space is typed, the current pseudo instruction is executed and the current value of the TPC is typed. If any other character is typed, step mode is exited.
SET CLOCK FAST	Sets the CPU clock speed to the fast margin.
SET CLOCK SLOW	Sets the CPU clock speed to the slow margin.
SET CLOCK NORMAL	Sets the CPU clock speed to normal.
SET CLOCK EXTERNAL	Sets the CPU clock for an external oscillator.
SHOW	Causes a display of the HD, HI, LOOP, NER, BELL, ERABT, LS, and LT flags.
LOOP	Clears the HD and HI flags. Sets the LOOP and NER flags and executes a continue command.
RETURN	Returns control to the console program.

Table 4-2 Microdiagnostic Command/Flag Descriptions (Cont)

Command/Flag	Description
Examine Commands	The following examine commands cause the current microinstruction to be executed before the examine is performed, if it is the first examine since entering the monitor command mode. All successive examines do not execute any additional microinstructions. ID Bus registers T1--T8 are destroyed during the examines, except for the V Bus examines. All of the following examines, except V Bus, advance the clock to CPT0 before executing the command.
EXAMINE ID:<ADDRESS>	Displays the content of the ID Bus register specified by <ADDRESS>.
EXAMINE VBUS:<CHANNEL>	Displays the content of the V BUS channel specified by <CHANNEL>. Bit 0 is at the right side of the display.
EXAMINE RA:<ADDRESS>	Displays the content of the RA scratch pad specified by <ADDRESS>.
EXAMINE RC:<ADDRESS>	Displays the content of the RC scratch pad specified by <ADDRESS>.
EXAMINE LA	Displays the content of the LA latch.
EXAMINE LC	Displays the content of the LC latch.
EXAMINE DR	Displays the content of the D register.
EXAMINE QR	Displays the content of the Q register.
EXAMINE SC	Displays the content of the SC register.
EXAMINE FE	Displays the content of the FE register.
EXAMINE VA	Displays the content of the VA register.
EXAMINE PC	Registers the content of the program counter.

Table 4-2 Microdiagnostic Command/Flag Descriptions (Cont)

Command/Flag	Description
Deposit Commands	The deposit command is the same as the examine command, except that the data to be deposited must be supplied by the user.
DEPOSIT ID: <ADDRESS> <DATA>	
DEPOSIT RA: <ADDRESS> <DATA>	
DEPOSIT RC: <ADDRESS> <DATA>	
DEPOSIT LA: <DATA>	
DEPOSIT LC: <DATA>	
DEPOSIT DR: <DATA>	
DEPOSIT QR: <DATA>	
DEPOSIT SC: <DATA>	
DEPOSIT FE: <DATA>	
DEPOSIT VA: <DATA>	
DEPOSIT PC: <DATA>	

4.6.1 Monitor Control Examples

The following paragraphs provide usage examples of selected monitor controls. These descriptions are brief and are intended only to indicate some of the capabilities of the microdiagnostic monitor.

4.6.1.1 HD/HI Flags -- In addition to testing, the microdiagnostics perform two basic functions: error detection and error isolation. Under normal circumstances, the user would set the HI flag. Setting the HI flag initiates the following microdiagnostic sequence:

- a. Error detection
- b. Call isolation routine to identify the error cause
- c. Display an error message identifying the failed test, data pattern used, and the failing modules
- d. Terminate test execution.

In a situation where the user does not require a scope loop, and wants to halt execution at the error detection point, the HD flag is set. This flag halts the test before the microdiagnostic calls the isolation routine overlay (e.g., V Bus compare).

4.6.1.2 Loop On Error Flag (LOOP) -- With this flag set, the microdiagnostic will revert to a tight program loop after error detection (assuming the NER flag is set). Note that the loop will continue even though the error is intermittent; the flag must be cleared to break the loop.

4.6.1.3 No Error Report Flag (NER) -- This flag suppresses the typing of error messages. The flag is especially useful in the case of looping on an error. Since the error printout takes time, the scope sync is lost during typing time. With error reports suppressed, the loop is tight and produces a reasonable sync.

4.6.1.4 Bell On Error Flag (BELL)

Hardcore Tests -- When running the hardcore tests, setting this flag causes the console terminal to ring its bell when an error occurs. This flag is useful in a situation where a manual adjustment could clear the error. In this situation, the user would set the LOOP flag and the NER flag, producing a tight loop.

However, with no error report, the user does not have an indication of where the error cleared during the adjustment. Setting the BELL flag is a compromise between a reasonably tight error loop (the BELL flag slows the loop somewhat) and an error indication during the adjustment. If a scope were used during the adjustment, the user would have an error indication without losing the scope trace.

Microtests -- In the microtests, one must loop on test (DI/TEST:n); then, after the error message has been printed, set the NER and BELL flags, clear the HI flag, and type CONTINUE.

4.6.1.5 Continue Command (CONT) -- This command allows the user to proceed from a microdiagnostic halt situation. For example, suppose that a hardware ECO, which has not been reflected in the diagnostic system, is incorporated into the computer. When the microdiagnostic halts following detection of the pseudo error, the user can bypass the failing test and continue execution at the next test by entering CONTINUE.

4.6.1.6 Error Abort Flag (ERABT) -- This flag allows the user to display more than one error report in certain hardcore tests (tests which exercise a particular piece of logic with more than one data pattern).

For example, consider the situation where the ERABT flag is set, and the test detects a type 2 error (ERROR2) on one of the initial data patterns. If the user were to enter CONTINUE, the flag would abort the remainder of the test and initiate execution of the next sequential test. However, with the flag cleared, CONTINUE will initiate execution of the same test with the next sequential data pattern.

4.7 MICRODIAGNOSTIC RELATED ERROR MESSAGES

The following paragraphs describe the microdiagnostic-related error message formats and their interpretation. All error messages are prefixed by a question mark to distinguish them from informational messages.

4.7.1 Syntax Error Messages

?USE DIAG COMMAND

Execution of a continue command was attempted before a diagnose command. This would only occur if TEST/COM were used to invoke the microdiagnostics from the console program.

?INVALID COMMAND

The previously entered command was not recognized.

?INVALID KEYWORD

The argument of a command was not recognized.

?NUMBER MUST BE HEX

A non-hexadecimal number was recognized.

4.7.2 System Error Messages

?OPEN FILE: <NUMBER>

An error was detected and identified while trying to open a floppy file. Error code is:

<NUMBER> = 1 = Floppy hardware error
<NUMBER> = 2 = File not found
<NUMBER> = 3 = Floppy not ready

?READ SECTOR: <NUMBER>

An error was detected and identified while trying to read a sector from the floppy. Error code is:

<NUMBER> = 4 = Sector number out of range
<NUMBER> = 3 = Floppy queue full
<NUMBER> = 1 = Floppy hardware error

?KEYBOARD ERROR: <NUMBER>

An error was detected and identified while trying to read the terminal. Error code is:

<NUMBER> = 5 = Terminal driver busy
<NUMBER> = 7 = Terminal hardware error

?UNEXPECTED TRAP TO 4 PC =

The LSI-11 trapped to 4 at the specified PC.

4.7.3 Go Chain Monitor Error Messages

?TIMEOUT IN TEST ... UPC =

Indicates that the microcode is hung. The monitor did not receive a call from the microcode in the last four seconds.

?EXECUTION OUT OF SEQUENCE UPC = SHOULD BE =

The microcode has not executed the tests within the overlay in sequential order.

?CLOCK STOPPED UNEXPECTEDLY

The clock stopped and the SOMM bit was not set.

?ILLEGAL MONITOR CALL: <NUMBER>

The microcode made a call to the monitor with a bad argument, which was <NUMBER>.

4.8 PROGRAM LISTING AND ERROR MESSAGE DESCRIPTIONS

The following paragraphs describe microdiagnostic program listings and error message formats. It is beyond the scope of this chapter to describe the various diagnostic program assemblers and their associated languages.

4.8.1 Monitor Listing Descriptions

The program listings for the microdiagnostic-associated monitors (i.e., microdiagnostic, hardcore, and microtest) share the same listing format. That is, since the three monitors operate out of the LSI-11, they are coded in MACRO-11 (PDP-11 assembly language) and are discussed as one in the general description.

Each listing is comprised of three general sections: Table of Contents, Program Definitions, and Program Code and Descriptions. Each page in a listing has a title containing the name of the program, the date the particular listing was generated, the page number, and a line item that indicates the content of that page (listing header) (Figure 4-5).

The Table of Contents is a list of the content of the program listing. The first (left) column contains a hyphenated number. The number preceding the hyphen specifies the page number of the listing on which the line appears. The number following the hyphen is a listing line number. This number specifies the starting line (within the listing) of the associated listing content contained in the right column (e.g., definitions, utility routines, test sections, etc.)

The Program Definition section specifies register address assignments, bit definitions, module and bus name assignments, and other constants that are used throughout the program.

The remainder of the listing (and the largest section by far) is the Program Code and Description section (Figure 4-5). The format is described on a per column basis from left to right. Note that the address and data radix for all monitor listings is octal.

- ^ Column 1, Listing Line Number -- Each line in the listing is assigned a unique decimal number to allow easy referencing from the Table of Contents.
- ^ Column 2, Address -- The address of the instruction.
- ^ Column 3, Content of the Address listed in Column 2 -- This is usually an instruction (e.g., reference line number 79 in Figure 4-5). The address is 101020, and its content is 032767, which is the octal code for a Bit Test (BIT) instruction.
- ^ Column 4 and 5 -- If the instruction is a two-word or three-word instruction, the second and third words are specified in columns 4 and 5, respectively (e.g., reference line number 79 in Figure 4-5). This BIT



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Figure 4-5 Monitor Listing Sample

instruction happens to be a three-word instruction, the second word is 040000, and the third word is 177064. Thus, this instruction is testing bit 14 (040000) to determine if the Control C flag is set at address 177064. (Note that this flag was defined in the definition section.)

- ^ Column 6, Label -- This symbol is the name used by the program mnemonics to reference this instruction (e.g., reference line number 95 in Figure 4-5). The label in this case is 12\$.
- ^ Column 7, Instruction Mnemonic -- This is the assembler language mnemonic for the instruction (e.g., Bit Test Instruction = BIT).
- ^ Column 8, Operand Definitions -- These symbols and mnemonics are the assembler language mnemonic definitions for the operands.
- ^ Column 9, Comments -- A brief description (following the semicolon) of the instruction operation.

4.8.2 Hardcore Listing Description

The general format of the hardcore listing is similar to that of the monitors (i.e., Table of Contents, Program Definitions, and Program Code and Descriptions). The left column of the Table of Contents contains a hyphenated number. The number preceding the hyphen specifies the page number of the listing on which the line appears. The number following the hyphen is the listing line number, indicating the starting line of the associated listing contents. The definition section is similar to the monitor listings, i.e., address, module and bus assignments, bit definitions, and other constants used in the program.

The remainder of the listing is the Program Code and Descriptions. As indicated in the Table of Contents, the hardcore tests are composed of sections and tests. The section number represents a 1.5K byte segment. The section number is displayed on the console terminal during hardcore test execution. The test number identifies a test on a particular logic area or function. The subtest number (which is not referenced in the Table of Contents) identifies a particular portion of a test. For example, Subtest 1 floats a logic one through each bit of a register; Subtest 2 floats a logic zero through the same register.

As shown in Figure 4-6, the program code is preceded by an outlined test header area. A subtitle statement (.SBTTL) generates the test number and title above the header area.

The header area consists of five descriptive segments. The first line within the outlined header repeats the test number and test title. The test description segment is a brief paragraph describing the general logic area tested and method of test. The logic description segment describes the test in more detail.

LISTING LINE NUMBER	ADDRESS	ADDRESS CONTENT	INSTRUCTION OPERANDS	COMMENTS
2530		.SBTTL TIC CS BUS DATA INTEGRITY		
		;*****		
		;++		
		;TEST 1C CS BUS DATA INTEGRITY		
		; TEST DESCRIPTION		
		; THIS TEST CHECKS THE DATA INTEGRITY OF THE CS BUS BY FLOATING		
		; A ONE AND A ZERO THRU A MICRO WORD, EXECUTING THE MICRO		
		; WORD, AND CHECKING THE V BUS FOR PARITY ERRORS.		
		;		
		; SUBTST 1 - FLOAT A ZERO THRU THE CS BUS		
		; SUBTST 2 - FLOAT A ONE THRU THE CS BUS		
		; LOGIC DESCRIPTION		
		; THIS TEST CHECKS THE ID BUS INTERFACE TO THE WCS MODULES, THE		
		; DATA INTEGRITY OF THE WCS MEMORY CHIPS AND THE DATA INTEGRITY OF		
		; THE CONTROL STORE (CS) BUS.		
		; ERROR DESCRIPTION		
		; DATA: EXPECTED V BUS CHANNEL, BIT AND VALUE		
		; RECEIVED V BUS CHANNEL, BIT AND VALUE		
		; LOOP COUNT - INDICATES WHICH BIT IN THE 32 BIT GROUP IS UNDER		
		; TEST, I.E. 1=BIT 0, 2=BIT 1, 3=BIT 2, ETC.		
		; LOOP COUNT - INDICATES WHICH 32 BIT GROUP IS UNDER		
		; TEST, I.E. 1= BITS<31:0>, 2=BITS<63:32>, 3=BITS<95:64>		
		;		
		; NOTE: THE EXPECTED AND RECEIVED V BUS CHANNEL INDICATES WHICH 32 BIT		
		; GROUP HAS BAD PARITY IN IT, I.E. 102X=BITS<31:00>,		
		; 101X=BITS<63:32>, AND 100X=BITS<95:64>.		
		; SYNC POINT DESCRIPTION		
		; SUBTST 1 - SYNC4C--TEST PATTERN IS ACTIVE ON THE CS BUS		
		; SUBTST 2 - SYNC4D--TEST PATTERN IS ACTIVE ON THE CS BUS		
		;--		
		;*****		
2534	000550	TIC:		
2535	000554	INITIALIZE		
2536	000556	SUBTEST		
		;//////////		
2537	000556	TICS1:		
2538		;+		
2539		; FIRST FLOAT A ZERO THRU THE CS BUS		
2540		;--		
2541	000560	LOOP	J,1,3	; LOOP COUNT FOR THE 3 BANKS
2542	000570	LDIDREG	USCADR,TMP100	; SELECT LOCATION ZERO
2543	000576	LOOP	K,1,3	; INITIALIZE THE CONTENTS OF LOCATION 0
2544	000606	LDIDREG	USCDAT,TMP102	; ...
2545	000614	ENDLOOP	K	; ...
2546				
2547	000620	LOOP	I,1,32	; LOOP COUNT FOR THE BITS IN A BANK
2548	000630	LDIDREG	USCADR,TMP100,J	; LOAD THE BANK ADDRESS
2549	000636	FLTZRO	TMP101,I	; GENERATE THE TEST PATTERN
2550	000644	ERLOOP		
2551	000646	LDIDREG	USCDAT,TMP101	; LOAD INTO THE SELECTED BANK
2552	000654	FETCH	10000	; EXECUTE THE MICRO WORD

Figure 4-6 Hardcore Listing Sample

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The error description segment specifies test parameters. For example, in the error description of Figure 4-6, the first line specifies what is expected during the test; the second line specifies what is received. The third line indicates which bit in the 32-bit array is under test; the fourth line indicates the 32-bit group under test. The sync point segment specifies critical points in the listing around which an error loop or scope loop might be set up (Paragraph 4.9.2).

Following the test header is the program code. The hardcore listings are described on a per column basis below.

- ^ Column 1, Listing Line Number -- Each line is assigned a unique decimal number to allow easy referencing.
- ^ Column 2, Address -- The relative address (PC) of the instruction.
- ^ Column 3, Address Content -- Content of the address listed in Column 2. (Note that the contents are the pseudo instructions described in Paragraph 4.4.2.)
- ^ Columns 4 and 5, Instruction Operands -- The operands are the instruction source, destination, or index values. The mnemonics appearing in these columns have been defined in the definition section of the listing.
- ^ Column 6, Comments -- A brief descriptive note concerning the instruction operation.

4.8.3 Microtest Listing Description

The general format of the microtest listing is somewhat similar to the other microdiagnostic listings, i.e., a Table of Contents, Program Definitions, and Program Code and Descriptions. However, since the microtests are executed out of the WCS, they are written in system microcode and, therefore, are similar to the system firmware listings. Unlike the hardcore listings that are assembled in one listing, the microtests are assembled into separate listings by 1K microword test sections and identified by those section numbers. Note also that the address and data radix for these listings is hexadecimal.

The Table of Contents is similar to those of the other listings; i.e., it contains a line number entry and the corresponding listing content description. Since the first column does not contain assembler directives, only the line number appears. The Program Definition section describes all macro definitions associated with the listing.

The Program Code and Description section format is similar to that of the system firmware listing. As in the hardcore listing, the program code is identical to the hardcore format and content described in Paragraph 4.8.2.

The microtest listing is described on a per column basis (Figure 4-7).

- ^ Column 1, UPC -- This column specifies the address contained in the UPC at that particular microstate.
- ^ Column 2, Microword -- This column describes the microword content of the address specified in column 1.
- ^ Column 3, Listing Line Number -- Decimal number assigned to allow easy referencing.
- ^ Column 4, Microstate Operation -- This column specifies the operation during a particular microstate. The notations used to describe the operation have been defined in the program definition section.
- ^ Column 5, Comments -- A brief descriptive note concerning the microstate operation. (A detailed firmware description is provided in the VAX-11/780 Central Processor Technical Description, e.g., field definitions, coding conventions, etc.)

4.8.4 Microdiagnostic Execution

The entire microdiagnostic package may be executed by entering TEST on the console terminal. Other operation options are described in the detailed diagnostic operating procedures in The VAX-11/780 Diagnostic System User's Guide (EK-DS780-UG-001). Following microdiagnostic identification the monitors initiate hardcore and microtest execution. Figure 4-8 illustrates typical console terminal output during error-free microdiagnostic execution.

The microtests and hardcore tests are numbered sequentially (with no duplication of test numbers). As shown in Figure 4-8, there is no differentiation between hardcore and microtests. A differentiation is required only in the case of an error (Paragraph 4.8.5).

The monitor loads the test, and the test section number is printed on the console terminal. Test execution is then initiated. The section number is printed (in hexadecimal) prior to execution to allow the operator to identify the exact failing section in the case of an error.

The entire microdiagnostic package requires two diskettes. As indicated in Figure 4-8, the microdiagnostic monitor instructs the operator when to mount the second diskette, and prompts for the command required to initiate execution of those diagnostics.

4.8.5 Error Message Format

The general error message format for both types of microdiagnostics is shown in Figure 4-9.

; DWN00A,MCR[400,3262] 12115 21-APR-1977		MICRO 31(241) Microcode file Page 7	
; DWN00A,MIC[400,3262] 14135 20-APR-1977		TEST A5 CES REGISTER ALU N BIT	
		1832	.PAGE "TEST A5 CES REGISTER ALU N BIT"
		1833	*****
		1834	;++
		1835	TEST A5 CES REGISTER ALU N BIT
		1836	;
		1837	TEST DESCRIPTION
		1838	THIS TEST CHECKS THE ALU N BIT IN THE CES REGISTER. THIS IS DONE
		1839	BY SELECTING THE ALU TO DO A+B AND A-B, AND F=B, WITH SPECIFIC
		1840	DATA PATTERNS ON THE AMX AND BMX TO CHECK THE LOGIC THAT GENERATES
		1841	THIS BIT.
		1842	;
		1843	SUBTST 1 - CHECK THE DATA PATTERNS THAT REQUIRE THE ALU TO
		1844	BE EXECUTING AN A+B TO GET THE CORRECT ALU DATA.
		1845	SUBTST 2 - CHECK THE DATA PATTERNS THAT REQUIRE THE ALU TO
		1846	BE EXECUTING AN A-B TO GET THE CORRECT ALU DATA.
		1847	SUBTST 3 - CHECK THE DATA PATTERNS THAT REQUIRE THE ALU TO
		1848	BE EXECUTING ANYTHIN BUT AN A+B OR A-B.
		1849	;
		1850	LOGIC DESCRIPTION
		1851	THIS TEST CHECKS THE LOGIC NETWORK ON THE CEH MODULE THAT GENERATES
		1852	THE ALU N BIT, AND THE MULTIPLEXOR ON THE ICL MODULE THAT FEEDS
		1853	THE ALU N BIT IN THE CES REGISTER.
		1854	;
		1855	ERROR DESCRIPTION
		1856	DATA: EXPECTED CES REGISTER
		1857	RECEIVED CES REGISTER
		1858	LOOP COUNT - INDICATES WHICH DATA PATTERN IS BEING USED.
		1859	(SEE THE DATA AT THE END OF THE TEST)
		1860	;
		1861	SYNC POINT DESCRIPTION
		1862	SUBTST 1 - SYNC1A--ALU N BIT GETS LOADED
		1863	SUBTST 2 - SYNC1B--ALU N BIT GETS LOADED
		1864	SUBTST 3 - SYNC1C--ALU N BIT GETS LOADED
		1865	--
		1866	*****
		1867	=0
U 1014, 0010,0039,0D80,09F0,0000,10F1		1868	ICLT0: NEWTST[.3]
U 1015, 0010,0030,6500,0A80,0000,1010		1869	R[0]_K[.10]
U 1018, 0000,003D,0100,0000,0000,1135		1870	=0 CALL,J/UNJAM
U 1019, 0010,0030,7500,0A80,0000,1140		1871	R[1]_K[.20]
U 1140, 0010,0030,7900,0A90,0000,1141		1872	R[2]_K[.30]
U 1141, 0010,0030,4100,0000,0000,1142		1873	D_K[.80]
U 1142, 0100,003C,0100,0000,0000,1143		1874	D=D,LEFT2
U 1143, 0001,003C,0100,0A90,0000,1144		1875	R[3]_D
		1876	;
		1877	////////////////////////////////////
		1878	++
		1879	DO THOSE FUNCTIONS REQUIRING THE ALU TO DO AN A PLUS B
		1880	--
		1881	;
U 1144, 0010,0030,0500,09E0,0000,101A		1882	T0S1: RC[0C]_K[.6]
U 101A, 0000,003D,0100,0000,0000,1124		1883	=0 SUBTEST
U 101B, 0000,003C,0100,0A00,0200,1145		1884	ICLT0L1:VA_R[0]
U 1145, 0000,003C,0100,C800,0000,1146		1885	D[BYTE]_CACHE,P
U 1146, 0001,003C,0100,0AA0,0000,1147		1886	R[5]_D
U 1147, 0000,003C,0100,0A00,0200,1148		1887	VA_R[1]
U 1148, 0000,003C,0100,C800,0000,1149		1888	D[BYTE]_CACHE,P
			;

MICRO
PROGRAM
COUNTER
(UPC)

MICROWORD
CONTENT

LINE
NUMBER

MICROSTATE
OPERATION

COMMENTS

Figure 4-7 Microtest Listing Sample

```

>>>TEST
MICRO DIAGNOSTIC V.05
01,02,03,
NO. OF WCS MODULES = 0001
04,05,06,07,08,09,0A,0B,0C,0D,0E,0F,10,11,12,13,14,15,16,17,
18,19,1A,1B,1C,1D,1E,1F,20,21,22,23,24,25,26,27,28,29,2A,2B,2C,2D,2E,
2F,30,31,32,33,34,35,36,37,38,39,3A,
END PASS 000001
MOUNT FLOPPY #2 & TYPE 'DI'
MIC>DI
3B,
# MEM CTRLS= 00000001
3C,3D,
4K CHIP 00000E08
3E,3F,
CPU TR= 00000010
40,41,42,43,44,45,46,47,48,49,4A,
CTRL 1 MAX ADR+1= 00080000
4B,
CTRL 1 MAX ADR+1= 00080000
4C,4D,
END PASS 000001

```

FIRST
TEXT
REFERENCE

SECOND
TEXT
REFERENCE

OPERATOR
INPUT
UNDERLINED

TK-0772

Figure 4-8 Typical Error-Free Terminal Output

```

ERROR: <PC> TEST: <#> SUBTEST: <#>

DATA:  XXXXXXXX
      XXXXXXXX
      .
      .
      .
      XXXXXXXX

TRACE:  W,X,Y,Z

FAILING MODULES: (M8269 (S13))...

NOTE:
PC IS OCTAL FOR HARDWARE TESTS,
OTHERWISE ALL NUMBERS ARE HEX.

```

TK-0750

Figure 4-9 Error Message Format

The first line items are ERROR, TEST, and SUBTEST. ERROR is the address (PC) of the failing test. In the case of a hardcore test error, the PC is displayed as a six-digit octal address, since these tests are executed out of the LSI-11. In the case of a microtest error, the PC is displayed as a four-digit hexadecimal address since it executes out of WCS.

TEST is the failing test number. Note that this is different from the section number sent to the console terminal during error-free execution. SUBTEST is the failing subtest number. These three first line items are important in referencing the program listings (Paragraph 4.9.2).

The DATA line item represents data used during the particular test. The number of data words displayed depends on the particular test. Generally, in the hardcore tests two words are displayed; the first word is the expected (or good) data, the second word is the received (or bad) data. However, as described in Paragraphs 4.8.2 and 4.8.3, the program listings contain a header describing the data patterns used.

The TRACE line item is involved in the fault isolation procedure in determining the set of modules responsible for the failure.

The last line item is FAILING MODULES. The output of this item represents the failing module and its backplane slot number. In some cases, the output will be several module numbers listed in the order of failure probability. However, in other cases the output will not be a module number. For example, consider the situation of a grounded ID Bus bit. The failure could appear to extend across all boards on the bus. Rather than printing out all related module numbers, the program would print out ID BUS.

4.9 LISTING/ERROR MESSAGE CORRELATION

This subsection provides basic direction in the use of error message content and its relationship to the program listings. The examples are included mainly to illustrate basic microdiagnostic capabilities.

4.9.1 No Error Message Situation

Consider the situation where the operator has initiated microdiagnostic execution using the TEST command. For one reason or another execution stops in the hardcore tests, and an error message is not printed. As shown in Figure 4-10, execution stops on test section 04.

The operator has a reasonable index into the hardcore test listings since section 04 is one of the initial sections executed. Referencing the section number in the hardcore listing Table of Contents, the operator finds that the section 04 description starts on listing line number 777.

CONSOLE TERMINAL OUTPUT

>>>TEST

MICRO DIAGNOSTIC V.05
01,02,03,
NO. OF WCS MODULES = 0001
02,

LISTING TABLE OF CONTENTS

MICRO DIAGNOSTIC HARDCORE TEST MACRO M10 20-APR-77 10:37
TABLE OF CONTENTS

TEST NUMBER INDEX	1- 5	CMPCA AND CMPCAM MODE DEFINITIONS	
	1- 5	SWITCH REGISTER BIT DEFINITIONS	
	1- 5	CONSOLE ADAPTER REGISTER DEFINITIONS	
	1- 5	ID BUS REGISTER DEFINITIONS	
	1- 5	MODULE AND BUS NAME ASSIGNMENTS	
	1- 6	SECTION NUMBER 01	
	2- 42	T01 CONSOLE ADAPTER REGISTER RESPONSE	
	3- 141	T02 CONSOLE "TO ID" REGISTER DATA INTEGRITY	
	4- 206	SECTION NUMBER 02	
	4- 206	T03 CONSOLE "MCR" REGISTER DATA INTEGRITY	
	5- 284	T04 CONSOLE "IDCS" REGISTER DATA INTEGRITY	
	6- 356	T05 CONSOLE RXDNE AND TXRDY REG DATA INTEGRITY	
	7- 439	T06 TXREADY AND RXDONE INTERRUPTS	
	8- 564	SECTION NUMBER 03	
	8- 564	T07 ID BUS DATA LINES DATA INTEGRITY	
	9- 661	T08 V BUS SELF TEST	
	10- 777	SECTION NUMBER 04	PROGRAM LISTING INDEX
	10- 777	T09 CONSOLE CLOCK CONTROL	
	11- 901	T0A CONSOLE ID CYCLE FUNCTION	
	12- 975	T0B CONSL FROM ID REG CLK CTRL & DATA INTEG	
	13-1070	SECTION NUMBER 05	
	13-1070	T0C CONSOLE MAINTENANCE RETURN	
	14-1162	T0D RXCS REGISTER FROM THE ID BUS SIDE	
	15-1282	SECTION NUMBER 06	
	15-1282	T0E TXCS REGISTER ON THE ID BUS	
	15-1367	SECTION NUMBER 07	
	16-1394	T0F ID BUS REGISTER ADDRESS INTEGRITY	
	16-1509	SECTION NUMBER 08	
	17-1535	T10 CIB INITIALIZE FUNCTION	
	17-1656	SECTION NUMBER 09	
	18-1677	T11 CONSOLE REGISTER DUAL ADDRESSING	
	19-1745	T12 WCS DATA REGISTER READ	
	20-1771	T13 INITIALIZE THE CONTROL STORE	
	21-1817	SECTION NUMBER 0A	
	21-1817	T14 WCS ADDRESS REGISTER DATA INTEGRITY	
	22-1906	T15 WCS ADDRESS REGISTER COUNT LOGIC	
	23-1976	T16 MICRO STACK DATA INTEGRITY	
	24-2061	SECTION NUMBER 0B	
	24-2061	T17 MICRO STACK DUAL ADDRESSING	
	25-2158	T18 MAINTENANCE RETURN DATA INTEGRITY	
	26-2327	SECTION NUMBER 0C	
	26-2327	T19 MAINTENANCE RETURN MICRO STACK INCREMENT	
	27-2372	T1A MICRO STACK WRITE DISABLE	
	28-2424	T1B WCS PARITY GENERATOR	
	29-2530	T1C CS BUS DATA INTEGRITY	
	30-2621	SECTION NUMBER 0D	
	30-2621	T1D PCS PARITY CHECKERS	
	31-2748	T1E WCS DUAL ADDRESSING	
	31-2807	SECTION NUMBER 0E	
	32-2845	T1F WCS DYNAMIC MEMORY TEST	
	33-2959	T20 UREN FIELD DECODE	
	34-3060	SECTION NUMBER 0F	
	34-3060	T21 USUB FIELD "CALL FUNCTION"	
	35-3168	T22 USUB FIELD "RETURN"	
	36-3229	SECTION NUMBER 10	
	36-3229	T23 USUB FIELD "SELECT SPECIFIER"	
	37-3365	T24 UJMP FIELD DATA INTEGRITY	

TK-0770

Figure 4-10 Listing Indexing Example

4.9.2 Hardcore Loop and Single Step Setup

During microdiagnostic execution the error message shown in Figure 4-11 is displayed on the console terminal. Since the error PC is a six-digit number (000670), it is an octal address and indicates a hardcore test. Referencing TEST: 1C in the hardcore Table of Contents indicates that the test begins on line 2530. Referencing the error PC of 000670 in the program code shows the PC to be at an IFERROR statement on line 2554.

The function of the IFERROR statement (Paragraph 4.4.2) is to produce an error report if a failure is encountered in the test. Usually the IFERROR statement is preceded by a check or compare function (in this case TSTVB). Basically this test is comparing V Bus signals. In this example, the received data did not match the expected data; consequently, an error was detected.

Since the hardcore tests execute out of the LSI-11, a scope loop may be too slow to be of practical use. An alternative is to use the set step instruction and loop commands of the microdiagnostic monitor. As indicated in Figure 4-11, the operator sets the single instruction and loop flags. In this case the loop range is between the statement following the previous ERLOOP statement (line 2551) and the IFERROR statement (line 2554). As shown in Figure 4-11, each time the operator types SPACE, the current PC is displayed. At TPC = 000662 the operator reaches sync point SYNC4C, at which time the operator could scope the CS Bus data bits in an attempt to detect the failing bit. (At this point in the test the microword has just been fetched from WCS and is driving the CS Bus.)

The operator can exit from the step mode by typing any character except SPACE. In the example, Control C has been typed and control returned to the microdiagnostic monitor command mode.

4.9.3 Microtest Scope Loop Setup

During microdiagnostic execution the error message shown in Figure 4-12 is sent to the console terminal. Note that execution stopped on test section 3A.

Since the error PC is a four-digit number (101E), it is a hexadecimal address and indicates a microtest. Using the test section number of 3A, and referencing the Table of Contents for that section, test A5 starts on line 1832. A look at the PC column (of the microtest listing) shows that the error PC is on line 1906.

By scanning back through the microcode, select a sync point, in this case SYNC1A on line 1901. Control is returned to the microdiagnostic monitor via Control C. The operator enters a CLEAR SOMM: <1153> command. This command will clear the stop on micromatch bit, and produce a sync pulse when the UPC equals the content of the microbreak register (i.e., 1153). The operator then enters a loop command. This sequence causes the test to begin looping and produce a sync pulse each time the UPC = 1153.

CONSOLE TERMINAL OUTPUT

```
>>>TEST
MICRO DIAGNOSTIC V.05
01,02,03,
NO. OF WCS MODULES = 0001
04,05,06,07,08,09,0A,0B,0C
```

```
ERROR: 000670 TEST: 1C SUBTEST: 1
DATA: 1010
      1011
      000A
      0002
TRACE: 000700,000720
FAILING MODULES: C.S. BUS
MIC>SET STEP INST )
MIC>LOOP )
TPC = 000646 (SPACE BAR)
TPC = 000654 (SPACE BAR)
TPC = 000662 X ← ANY CHAR. TO RESUME
                FULL SPEED.
↑C ← CONTROL -C TO RETURN TO MONITOR
MIC>
```

↑
OPERATOR
INPUT
UNDERLINED

ERROR
PC
INDEX

LISTING TABLE OF CONTENTS

MICRO DIAGNOSTIC HARDCORE TEST		MACRO M10	20-APR-77 10:37
TABLE OF CONTENTS			
1-	5	CMPCA AND CMPCAM MODE DEFINITIONS	
1-	5	SWITCH REGISTER BIT DEFINITIONS	
1-	5	CONSOLE ADAPTER REGISTER DEFINITIONS	
1-	5	ID BUS REGISTER DEFINITIONS	
1-	5	MODULE AND BUS NAME ASSIGNMENTS	
1-	6	SECTION NUMBER 01	
2-	42	T01 CONSOLE ADAPTER REGISTER RESPONSE	
3-	141	T02 CONSOLE "TO ID" REGISTER DATA INTEGRITY	
4-	206	SECTION NUMBER 02	
4-	206	T03 CONSOLE "MCR" REGISTER DATA INTEGRITY	
5-	284	T04 CONSOLE "IDCS" REGISTER DATA INTEGRITY	
6-	356	T05 CONSOLE RXDNE AND TXRDY REG DATA INTEGRITY	
7-	439	T06 TXREADY AND RXDONE INTERRUPTS	
8-	564	SECTION NUMBER 03	
8-	564	T07 ID BUS DATA LINES DATA INTEGRITY	
9-	661	T08 V BUS SELF TEST	
10-	777	SECTION NUMBER 04	
10-	777	T09 CONSOLE CLOCK CONTROL	
11-	901	T0A CONSOLE ID CYCLE FUNCTION	
12-	975	T0R CONSL FROM ID REG CLK CTRL & DATA INTEG	
13-	1070	SECTION NUMBER 05	
13-	1070	T0C CONSOLE MAINTENANCE RETURN	
14-	1162	T0D RXCS REGISTER FROM THE ID BUS SIDE	
15-	1282	SECTION NUMBER 06	
15-	1282	T0E TXCS REGISTER ON THE ID BUS	
15-	1367	SECTION NUMBER 07	
16-	1394	T0F ID BUS REGISTER ADDRESS INTEGRITY	
16-	1509	SECTION NUMBER 08	
17-	1535	T10 CIB INITIALIZE FUNCTION	
17-	1656	SECTION NUMBER 09	
18-	1677	T11 CONSOLE REGISTER DUAL ADDRESSING	
19-	1745	T12 WCS DATA REGISTER READ	
20-	1771	T13 INITIALIZE THE CONTROL STORE	
21-	1817	SECTION NUMBER 0A	
21-	1817	T14 WCS ADDRESS REGISTER DATA INTEGRITY	
22-	1906	T15 WCS ADDRESS REGISTER COUNT LOGIC	
23-	1976	T16 MICRO STACK DATA INTEGRITY	
24-	2061	SECTION NUMBER 0B	
24-	2061	T17 MICRO STACK DUAL ADDRESSING	
25-	2158	T18 MAINTENANCE RETURN DATA INTEGRITY	
26-	2327	SECTION NUMBER 0C	
26-	2327	T19 MAINTENANCE RETURN MICRO STACK INCREMENT	
27-	2372	T1A MICRO STACK WRITE DISABLE	
28-	2424	T1B WCS PARITY GENERATOR	
29-	2530	T1C CS BUS DATA INTEGRITY	
30-	2621	SECTION NUMBER 0D	
30-	2621	T1D PCS PARITY CHECKERS	
31-	2748	T1E WCS DUAL ADDRESSING	
31-	2807	SECTION NUMBER 0E	
32-	2845	T1F WCS DYNAMIC MEMORY TEST	
33-	2959	T20 USBN FIELD DECODE	
34-	3060	SECTION NUMBER 0F	
34-	3060	T21 USUB FIELD "CALL FUNCTION"	
35-	3168	T22 USUB FIELD "RETURN"	
36-	3229	SECTION NUMBER 10	
36-	3229	T23 USUB FIELD "SELECT SPECIFIER"	
37-	3365	T24 UJMP FIELD DATA INTEGRITY	

PAGE #

HARDCORE PROGRAM LISTING

PAGE #

```
MICRO DIAGNOSTIC HARDCORE TEST MACRO M10 20-APR-77 10:37 PAGE 29
T1C CS BUS DATA INTEGRITY
2530
,SBTTL T1C CS BUS DATA INTEGRITY
;*****
;TEST 1C CS BUS DATA INTEGRITY
;
; TEST DESCRIPTION
; THIS TEST CHECKS THE DATA INTEGRITY OF THE CS BUS BY FLOATING
; A ONE AND A ZERO THRU A MICRO WORD, EXECUTING THE MICRO
; WORD, AND CHECKING THE V BUS FOR PARITY ERRORS.
;
; SUBST 1 = FLOAT A ZERO THRU THE CS BUS
; SUBST 2 = FLOAT A ONE THRU THE CS BUS
;
; LOGIC DESCRIPTION
; THIS TEST CHECKS THE ID BUS INTERFACE TO THE WCS MODULES, THE
; DATA INTEGRITY OF THE WCS MEMORY CHIPS AND THE DATA INTEGRITY OF
; THE CONTROL STORE (CS) BUS.
;
; ERROR DESCRIPTION
; DATA: EXPECTED V BUS CHANNEL, BIT AND VALUE
; RECEIVED V BUS CHANNEL, BIT AND VALUE
; LOOP COUNT = INDICATES WHICH BIT IN THE 32 BIT GROUP IS UNDER
; TEST, I.E. 1=BIT 0, 2=BIT 1, 3=BIT 2, ETC.
; LOOP COUNT = INDICATES WHICH 32 BIT GROUP IS UNDER
; TEST, I.E. 1= BITS<31:0>, 2=BITS<63:32>, 3=BITS<95:64>
;
; NOTE: THE EXPECTED AND RECEIVED V BUS CHANNEL INDICATES WHICH 32 BIT
; GROUP HAS BAD PARITY IN IT, I.E. 102X=BITS<31:0>,
; 101X=BITS<63:32>, AND 100X=BITS<95:64>.
;
; SYNC POINT DESCRIPTION
; SUBST 1 = SYNC4C--TEST PATTERN IS ACTIVE ON THE CS BUS
; SUBST 2 = SYNC4D--TEST PATTERN IS ACTIVE ON THE CS BUS
;==
;*****
T1C: INITIALIZE
SUBTEST
;////////////////////////////////////
T1CS1:
;+
; FIRST FLOAT A ZERO THRU THE CS BUS
;=
LOOP J,1,3 ; LOOP COUNT FOR THE 3 BANKS
LDIDREG USCADR,TMP100 ; SELECT LOCATION ZERO
LOOP K,1,3 ; INITIALIZE THE CONTENTS OF LOCATION 0
LDIDREG USCDAT,TMP102 ; ...
ENDLOOP K ; ...
LOOP I,1,32 ; LOOP COUNT FOR THE BITS IN A BANK
LDIDREG USCADR,TMP100,J ; LOAD THE BANK ADDRESS
FLTZRO TMP101,I ; GENERATE THE TEST PATTERN
ENDLOOP
LDIDREG USCDAT,TMP101 ; LOAD INTO THE SELECTED BANK
FETCH 10000 ; EXECUTE THE MICRO WORD
;
; SYNC POINT
MICRO DIAGNOSTIC HARDCORE TEST MACRO M10 20-APR-77 10:37 PAGE 29-1
T1C CS BUS DATA INTEGRITY
2553 000662 SYNC4C: TSTVB TMP103 ; CHECK THAT THERE WAS NO PARITY ERROR
2554 000670 IFERROR 30,CSERR ;
2555 000676 ENDLOOP I ; CONTINUE WITH THE NEXT BIT
2556 000702 ENDLOOP J ; CONTINUE WITH THE NEXT BANK
2557 000706 SKIP SUBST
2558
2559 000712 CSERR: REPORT <CSBUS> ; CS BUS BIT(S) STUCK
2560
2561 000722 SUBTEST
;////////////////////////////////////
000722 T1CS2:
```

Figure 4-11 Loop and Single Example

MICROTEST PROGRAM LISTING

ERROR
- PC
INDEX

TEST
NUMBER
INDEX

TEST
STARTING
— LINE
NUMBER

```

U 1144, 0018,0038,D500,09E0,0000,101A
U 101A, 0000,003D,0180,0800,0000,1124
U 101B, 0000,003C,0180,0A00,0200,1145
U 1145, 0000,003C,0180,C000,0000,1146
U 1146, 0001,003C,0180,0A08,0000,1147
U 1147, 0000,003C,0180,0A08,0200,1148
U 1148, 0000,003C,0180,C000,0000,1149
U 1149, 0001,003C,0180,09A8,0000,114A
U 114A, 0000,003C,0180,0A10,0200,114B
U 114B, 0000,003C,0180,C000,0000,114C
U 114C, 0002,003C,0180,0800,0000,114D
U 114D, 0001,003C,0180,09F0,0000,101C
U 101C, 0000,003D,0180,0800,0000,10FD
U 101D, 0010,0038,0180,0970,0000,114E
U 114E, 0001,0028,0180,0800,0000,114F
U 114F, 001C,2034,0180,0A18,0000,1150
U 1150, 0010,0038,3180,3D70,0000,1151
U 1151, 0000,003C,0180,0A28,0000,1152
U 1152, 0000,003C,0180,0920,0000,1153
U 1153, 0010,0014,0180,0800,0010,1154
U 1154, 0000,003C,31F0,2C00,0000,1156
U 1156, 001C,0034,01C0,0A18,0000,1157
U 1157, 001D,2000,0180,0000,0A10,115E
U 1158, 0000,013C,0180,0800,0000,101E
U 101E, 0001,203D,0180,09E8,0000,1109
U 101F, 0000,003C,0180,0A00,0000,1159
U 1159, 0010,0014,0580,0A00,0000,115A
U 115A, 0000,003C,0180,0A00,0000,115B
U 115B, 0010,0014,0580,0A08,0000,115C

```

```

1832 .PAGE "TEST A5 CES REGISTER ALU N BIT"
1833 ;*****
1834 ;
1835 ; TEST A5 CES REGISTER ALU N BIT
1836 ;
1837 ; TEST DESCRIPTION
1838 ; THIS TEST CHECKS THE ALU N BIT IN THE CES REGISTER. THIS IS DONE
1839 ; BY SELECTING THE ALU TO DO A+B AND A-B, AND F=B, WITH SPECIFIC
1840 ; DATA PATTERNS ON THE AMX AND BMX TO CHECK THE LOGIC THAT GENERATES
1841 ; THIS BIT.
1842 ;
1843 ; SUBTST 1 - CHECK THE DATA PATTERNS THAT REQUIRE THE ALU TO
1844 ; BE EXECUTING AN A+B TO GET THE CORRECT ALU DATA.
1845 ; SUBTST 2 - CHECK THE DATA PATTERNS THAT REQUIRE THE ALU TO
1846 ; BE EXECUTING AN A-B TO GET THE CORRECT ALU DATA.
1847 ; SUBTST 3 - CHECK THE DATA PATTERNS THAT REQUIRE THE ALU TO
1848 ; BE EXECUTING ANYTHIN BUT AN A+B OR A-B.
1849 ;
1850 ; LOGIC DESCRIPTION
1851 ; THIS TEST CHECKS THE LOGIC NETWORK ON THE CEH MODULE THAT GENERATE
1852 ; THE ALU N BIT, AND THE MULTIPLEXOR ON THE ICL MODULE THAT FEEDS
1853 ; THE ALU N BIT IN THE CES REGISTER.
1854 ;
1855 ; ERROR DESCRIPTION
1856 ; DATA: EXPECTED CES REGISTER
1857 ; RECEIVED CES REGISTER
1858 ; LOOP COUNT - INDICATES WHICH DATA PATTERN IS BEING USED.
1859 ; (SEE THE DATA AT THE END OF THE TEST)
1860 ;
1861 ; SYNC POINT DESCRIPTION
1862 ; SUBTST 1 - SYNC1A--ALU N BIT GETS LOADED
1863 ; SUBTST 2 - SYNC1B--ALU N BIT GETS LOADED
1864 ; SUBTST 3 - SYNC1C--ALU N BIT GETS LOADED
1865 ;--
1866 ;*****
1867 ;=0
1868 ICLT8: NEWTST[,3]
1869 R[0]_K[,10] ; ADDRESS OF AMX DATA
1870 ;=0 CALLJ/JUNJAM ; CLEAR ANY SBI INTERRUPTS
1871 R[1]_K[,20] ; ADDRESS OF BMX DATA
1872 R[2]_K[,30] ; ADDRESS OF EXPECTED ALU N BIT
1873 D_K[,80]
1874 D_D,LEFT2 ; GENERATE MASK FOR N BIT
1875 R[3]_D ; SAVE
1876
1877 ;////////////////////
1878 ;+
1879 ; DO THOSE FUNCTIONS REQUIRING THE ALU TO DO AN A PLUS B
1880 ;=
1881
1882 T8S1: RC[0C]_K[,6] ; SET THE LOP COUNT
1883 ;=0 SUBTEST
1884 ICLT8L1:VA_R[0]
1885 D[BYTE]_CACHE,P ; FETCH AMX DATA
1886 R[5]_D ; SAVE
1887 VA_R[1]
1888 D[BYTE]_CACHE,P ; FETCH BMX DATA
1889 RC[5]_D ; SAVE
1890 VA_R[2]
1891 D[WORD]_CACHE,P ; FETCH EXPECTED N BIT DATA
1892 D_D,SXT[WORD]
1893 RC[0E]_D ; SAVE
1894 ;=0 ERLOOP
1895 ; D_RC[0E]
1896 D_NOT,D ; GENERATE INITIAL VALUE OF N BIT
1897 D_D,AND,R[3] ; MASK
1898 ID[CES]_D,D_RC[0E] ; INIT THE CES REGISTER
1899 LAB_R[5]
1900 LC_RC[5] ; LATCH AMX AND BMX DATA
1901 SYNC1A: ALU_LA+LC,CLK,UBCC,BYTE ; EXECUTE THE TEST
1902 Q_ID[CES]
1903 Q_Q,AND,R[3] ; MASK
1904 ALU_Q=D,CLK,UBCC ; CHECK
1905 ZT
1906 ;=0 ERROR2,RC[0D]_Q ; ALU N BIT FAILED IN CES REG
1907 LAB_R[0]
1908 R[0]_LA+K[,1] ; INCREMENT ADR OF AMX DATA
1909 LAB_R[1]
1910 R[1]_LA+K[,1] ; INCREMENT ADR OF BMX DATA

```

Figure 4-12 Microtest Scope Loop Example

As shown in Figure 4-12, the operator has entered a Control C followed by a RETURN (RET) command. This sequence breaks the test loop and returns control to the console program.

4.9.4 Microtest Single Bus Step Setup

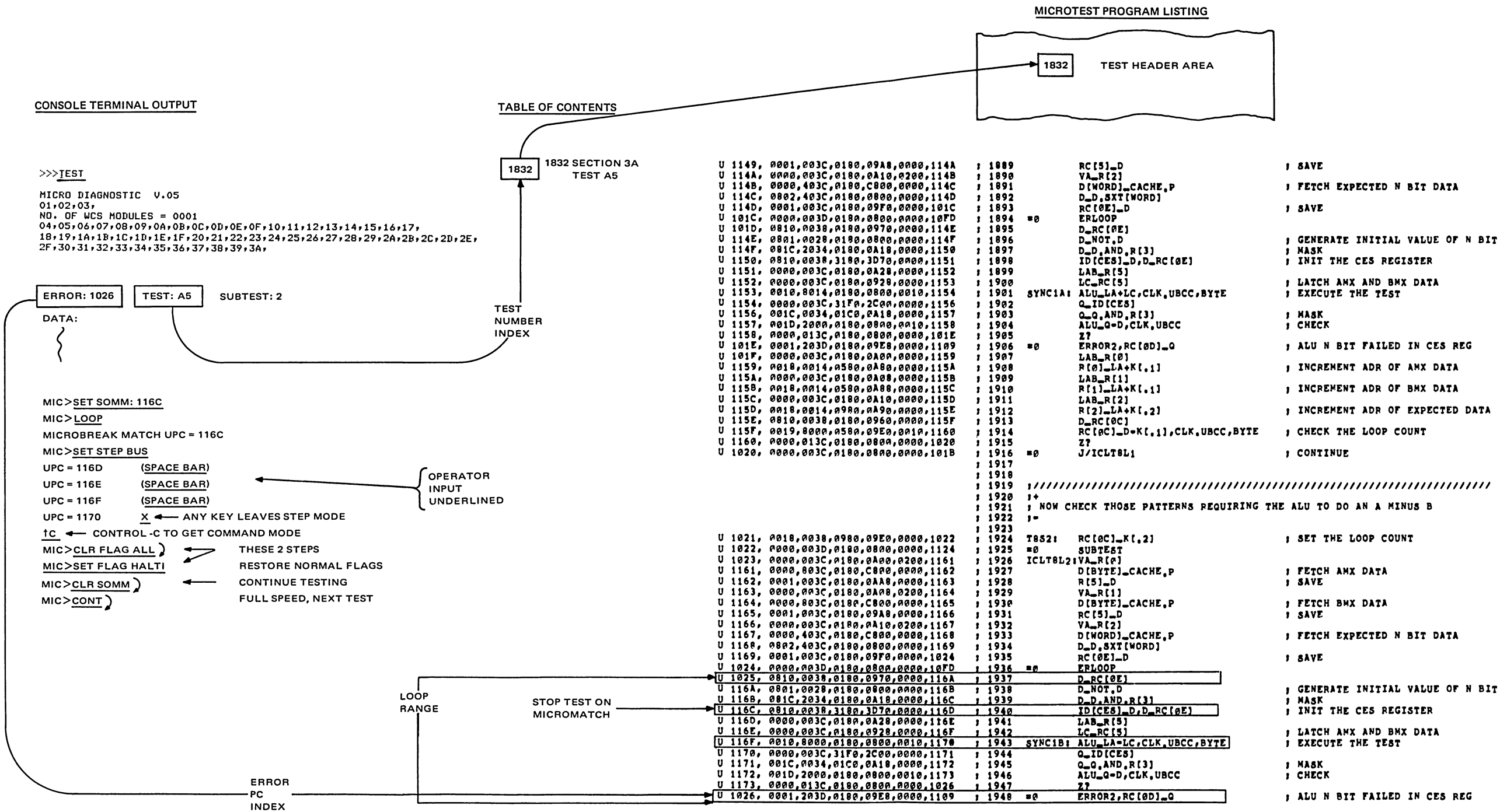
During microdiagnostic execution the error message shown in Figure 4-13 is printed on the console terminal. As in the previous example, execution stopped on test section 3A.

As in Paragraph 4.9.3, the error PC is a four-digit number indicating a microtest. A look at the section 3A listing indicates that the error PC is on line 1948. At this point it is decided to use the single bus step capability.

A scan backward through the microcode indicates a possible loop between SYNC1B (line 1943) and ERLOOP (line 1936). A point in the loop is chosen to stop the microtest, in this case UPC 116C (line 1940). The operator enters SET SOMM: 116C, which sets the stop on micromatch bit and loads 116C into the microbreak register. A loop command is then entered which initiates execution of the loop. When the loop reaches UPC 116C, the microtest halts and prints the UPC on the console terminal.

At this point, the operator enters the bus cycle mode (set step bus command). Each time the operator types SPACE, a single bus cycle is executed and the UPC is displayed on the console terminal. At any point in the loop the operator may scope the current conditions.

As shown in Figure 4-13, the operator has exited from step mode by typing any character other than SPACE. The program control flags previously set are cleared. The HI flag is set to restore the normal default case. A CLEAR SOMM is then performed to clear the stop on micromatch bit and the microbreak register, then a CONTINUE is performed to begin normal test execution at the next sequential test (i.e., A6). If the operator feels that the problem has been cleared, it is probably more practical to start the tests over rather than to begin at the next test.



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Figure 4-13 Microtest Single Bus Example

CHAPTER 5 MACRODIAGNOSTIC PROGRAM DESCRIPTIONS

5.1 DEFINITION OF TERMS

Module -- The diagnostic programs are written in a modular format. Each module (file) is a part of the program assembled separately. Modular programming allows the development of large programs in which separate parts share data and routines.

Assembler -- The MARS assembler (which runs on a PDP-11) and the VAX-11 Macro assembler (which runs on a VAX-11) are programs that accept one or more source modules written in MACRO assembly language and produce relocatable object modules and symbol tables.

Linker -- The VAX/VMS linker and the cross linker accept as input one or more native code object modules produced by the assembler. Linking consists of three basic operations.

1. Allocation of virtual memory addresses
2. Resolution of intermodule symbolic references (global symbols)
3. Initialization of the contents of a memory image.

Program Defined Symbols -- Program defined symbols (and labels) are either internal or external (global) to a source program module. An internal symbol definition (and reference) is limited to the module in which it appears. Internal symbols used by the diagnostics are temporary definitions that are resolved by the assembler.

A global symbol can be defined in one source program module and referenced by another. Global symbols are preserved in the object module and are not resolved until the object modules are linked into an executable program by the linker.

Program Sections -- The assembler creates a number of program sections (.PSECT) within a module, according to directives by the program developer. In addition, any code that precedes the first defined program section is placed in the BLANK program section by the assembler.

Through program sectioning the program developer controls the virtual memory allocation of a program. Any program attributes established by the program section directive are passed on to the linker. Thus program sections can be declared as read-only, non-executable, etc. Refer to the VAX-11 MACRO Language Reference Manual for an explanation of the various program section attribute functions.

In the diagnostic programs, each test is given a separate program section.

5.2 OVERVIEW OF THE MACRODIAGNOSTIC PROGRAM

The macrodiagnostic programs and the diagnostic supervisor are written in VAX-11 native code. Each of the programs (and the supervisor) consists of modules. These modules are separate files, which are assembled separately and then linked by the linker program. Each module contains one or more program sections. The program sections and routines are organized according to a common format and a set of conventions that enable them to interact with the supervisor. Note that the listings described in this chapter are those assembled by the MARS assembler and linked by the cross linker in compatibility mode. The format will change when the native assembler and linker are used.

5.3 MACRODIAGNOSTIC PROGRAM LISTING DESCRIPTION

This section describes the program listings in general terms. Illustrations and examples are taken from the MBA RH780 diagnostic program. The formats of the other listings are similar.

Each program listing begins with user information and a link map created by the linker program. The separate modules that make up the program constitute the rest of the listing. The first module, called the header, defines symbols and labels and provides routines that are called by other modules. The modules which follow contain the test routines.

User Information -- The user information, which comes at the beginning of the listing, includes the following items.

- Program identification
- Copyright statement
- Program abstract
- Hardware and software requirements
- Prerequisites to running the program
- Load and start instructions
- Program description
- History of program maintenance

Link Map -- The link map shows the virtual memory allocation of the total program image in the program section allocation synopsis. Figure 5-1 shows this synopsis for the MBA diagnostic listing.

The program section allocation synopsis lists the program sections according to the order in which they appear in memory. A list of attributes and the base, end, and length are given for each program section. The base address is the virtual address of the first location in each program section assigned at link time. This number must be added to the relative addresses given in the module listings to determine the virtual addresses of specific instructions because the assembly addresses are all relative to the base of the program section.

VIRTUAL MEMORY ALLOCATION OF IMAGE "ESCAA.EXE;1"
THIS ALLOCATION WAS DONE ON 20-SEP-78
AT 12:43 BY CROSS LINKER VERSION X4.6

VIRTUAL MEMORY LIMITS: 00000200 0000B5FF 0000B400
STACK SIZE (DEC. PAGES): 10
VIRTUAL DISK BLOCK LIMITS (OCTAL): 0000001 000132 000132
IDENTIFICATION: 5.3
DYNAMIC MEMORY AVAILABLE (BYTES): 42752
DYNAMIC MEMORY USED (BYTES): 20648
LARGEST FREE HOLE SIZE: 21248
NUMBER OF HOLES FREE: 00079
47 HOLES OF 4 BYTES
11 HOLES OF 8 BYTES
4 HOLES OF 12 BYTES
5 HOLES OF 16 BYTES
4 HOLES OF 20 BYTES
5 HOLES OF 24 BYTES
1 HOLES OF 32 BYTES
1 HOLES OF 180 BYTES
NUMBER OF P-SECTS DEFINED: 00034
NUMBER OF GLOBAL SYMBOLS: 00570

PROGRAM SECTION ALLOCATION SYNOPSIS:

NAME	ATTRIBUTES					BASE	END	LENGTH
<\$ABSS>:	NOPIC,	USR,	CON,	ABS,	LCL,NOSHR, EXE, RD , WRT	00000000	00000000	00000000
<\$HEADER>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR,NOEXE, RD ,NOWRT	00000200	00000281	00000082
<\$STCNT>:	NOPIC,	USR,	QVR,	REL,	LCL,NOSHR,NOEXE, RD ,NOWRT	00000284	00000287	00000004
< . ABS .>:	NOPIC,	USR,	CON,	ABS,	LCL,NOSHR,NOEXE,NORD ,NOWRT	00000000	00000000	00000000
< . BLANK .>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD , WRT	00000288	00001AB8	00001831
<ARGLIST>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD ,NOWRT	00001ABC	00001E63	000003A8
<BUFFERS>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR,NOEXE, RD , WRT	00002000	000025FF	00000600
<CLEANUP>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXF, RD , WRT	00002600	0000266F	00000070
<DISPATCH>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR,NOEXE, RD ,NOWRT	00002670	0000284F	000001E0
<DISPATCH_X>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR,NOEXE, RD ,NOWRT	00002850	00002867	00000018
<HEADER_CODE>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD ,NOWRT	00002A00	00002E3A	0000043B
<INITIALIZE>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD , WRT	00002E3C	00003091	00000256
<SUMMARY>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD , WRT	00003094	0000309D	0000000A
<TEST_001>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD ,NOWRT	00003200	00003355	00000156
<TEST_002>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXF, RD ,NOWRT	00003400	0000369B	0000029C
<TEST_003>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD ,NOWRT	00003800	00003987	00000188
<TEST_004>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD ,NOWRT	00003A00	00004152	00000753
<TEST_005>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD ,NOWRT	00004200	000042A7	000000A8
<TEST_006>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD ,NOWRT	00004400	000045E1	000001E2
<TEST_007>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD ,NOWRT	00004600	00004773	00000174
<TEST_008>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD ,NOWRT	00004800	000051FC	000009FD
<TEST_009>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD ,NOWRT	00005200	00005AD7	000008D8
<TEST_010>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD ,NOWRT	00005C00	00005E0B	0000020C
<TEST_011>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD ,NOWRT	00006000	0000679D	0000079E
<TEST_012>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD ,NOWRT	00006800	00006A59	0000025A
<TEST_013>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD ,NOWRT	00006C00	00006F2F	00000330
<TEST_014>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD ,NOWRT	00007000	00007615	00000616
<TEST_015>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD ,NOWRT	00007800	00007A2E	0000022F
<TEST_016>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD ,NOWRT	00007C00	00008FFC	000013FD
<TEST_017>:	NOPIC,	USR,	CON,	REL,	LCL,NOSHR, EXE, RD ,NOWRT	00009000	00009158	00000159

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Figure 5-1 Portion of the
Program Section Synopsis,
RH780 (MBA) Diagnostic Program

The link map also lists the global symbols and their assigned values. Note that symbols used as labels point to routines in the diagnostic supervisor, if their values are over 100000.

Figure 5-2 shows a portion of the global symbol table for the absolute program section in the header file of the MBA diagnostic program.

The link map is a part of the listing created by the linker, but not a part of the actual program in memory. It always precedes the first file in the macrodiagnostic program listings.

Header Module -- Like all of the modules in the program, the header module begins with a Table of Contents, a Copyright Statement, and a Revision History.

The declarations section in the header module contains global symbol definitions for register bit names, data patterns, masks referenced by the program, and Macro definitions. This section constitutes the beginning of the program code. The own storage section in the header module contains program labeled data, such as drive addresses, and program text and format statements, containing the ASCII texts of error and status messages.

The header module also contains code that generates the hardware and software parameter tables, report and print routines, initialization and clean up routines, and interrupt and exception service routines.

The assembler prints a symbol table and a program section synopsis for the entire module following the last program section in the module.

Test Modules -- The remaining modules in the program contain the tests, which are the main body of the program. Each module begins with a Table of Contents, Copyright Statement, and Program Maintenance History. The program code begins with macro definitions. A symbol table and program section synopsis are provided by the assembler following the last program section for each test module. Notice that each test begins a new program section.

SEQ.	NAME	ALIGNMENT	BASE	END	LENGTH	
0	<. ABS .>:	BYTE 0	00000000	00000000	00000000	
GLOBAL SYMBOLS DEFINED:-						
	\$ENV	00000001	\$MO	00000001	ASSA	0000A55A
	AASS	0000A555	ADAPTER_CODE	00000020	ALL	00000001
	ALL_ONES	0000FFFF	ASP_OFFSET	00000416	ATA	00008000
	ATTENTION	00010000	ATTN	00000018	BCR	00000010
	BLKSCSBI	0000001C	BLKSNDR_CMD	10000000	BR0	00000010
	BR1	00000011	BR2	00000012	BR3	00000013
	BR4	00000014	BR5	00000015	BR6	00000016
	BR7	00000017	BYTE0	000000FF	BYTE1	0000FF00
	BYTE2	00FF0000	BYTE3	FF000000	BYTE_COUNT_MSK	0000FFFF
	CAR	0000001C	CPF	00000008	CR	00000004
	CRTRD_READ_DATA	20000000	CSR	00000000	DATA_XFER_ABORT	00001000
	DATA_XFER_DONE	00002000	DATA_XFER_LATE	00000800	DEFAULT	00000000
	DISABLE_LOG	30000000	DMD	00000001	DOCC	00000100
	DPE	00000010	DPR	00000100	DR	00000014
	DRIVE_OFFSET	00000080	DRIVE_SEL_MSK	0000E000	DRV_ERRMASK	0000E000
	DRV_INITMASK	00001180	DRY	00000080	DS_MSK	0FFFF8FF
	DTE	00001000	DT_ABORT	00000002	DT_BUSY	80000000
	DVA	00000080	EPL	0000001A	ENABLE_PS	00000800
	ERR	00004000	ERR_CONF	00000008	EXT_REG_OFFSET	00000400
	F00F	0000F00F	FATL	00000013	FERR	00000004
	FORCE_MEMERR	000002FF	HPSA_CHANNEL	00000014	HPSA_DEVICE	00000018
	HPSB_BR	00000021	HPFR_DRIVE	00000022	HPSB_SLAVE	00000023
	HPSB_TR	00000020	HPSL_IRQVEC	00000024	HPSL_VECTOR	0000001C
	HPSQ_DEVICE	00000000	HPST_DEVICE	00000008	ILF	00000001
	IMAPP	00000010	IMBCP	0000001E	IMBDP	0000001F
	INTERRUPT_ENABLE	00000004	INT_SEQ_TIMEOUT	00000002	INVRT_MAP_PAR	20000000
	INVRT_MB_CPAR	40000000	INVRT_MB_DPAR	80000000	IO_PAGE	20000000
	IPLR	00000012	LOWRITS_MSK	0000003F	MAINT_MODE	00000008
	MANUAL	00000002	MAP_I_PATRN	801FFFFF	MAP_INVALID	00000010
	MAP_OFFSET	00000800	MAP_PE	00000020	MAP_PTR_MSK	0001FE00
	MASS_CNTRL_PE	00020000	MASS_CTOD	00010000	MASS_DATA_PE	00000040
	MASS_ECP	00000080	MASS_EXCP	00020000	MASS_FATL	00100000
	MASS_RUN	00080000	MASS_WCLK	00040000	MBIB_SEL	00800000
	MBE	00000003	MBE_ASR	00000010	MBE_CR1	00000000
	MBE_CR2	00000014	MBE_DRR	0000001C	MBE_DTR	00000018
	MBE_ER	00000008	MBE_MR	0000000C	MBE_PARAM	00000087
	MBE_SR	00000004	MCLK	00000002	MISSED_XFER	00000100
	MOL	00001000	MSR	00000018	MULT_TX	08000000
	NEXUS_OFFSET	00002000	NIRBLE0	0000000F	NIRBLE1	000000F0
	NIRBLE2	00000F00	NIRBLE3	0000F000	NIRBLE4	000F0000
	NIRBLE5	00F00000	NIRBLE6	0F000000	NIRBLE7	F0000000
	NON_XIST_DRIVE	00040000	NOOP	00000000	NO_RESP_CONF	40000000
	OCC	00000019	OPI	00002000	PAGE_BYTE_MSK	000001FF
	PF_FIELD	00000000	PF_WIDTH	00000015	PGM_INIT	00000001
	PIP	00002000	POWER_DOWN	00800000	POWER_UP	00400000

Figure 5-2 Portion of the
Global Symbol Table for the
Absolute PSECT of the Loader
File of the RH780 (MBA)
Diagnostic Program

5.4 DIAGNOSTIC PROGRAM AND SUPERVISOR INTERACTION

Whether a diagnostic program is executed in the user mode or in the standalone mode, its relation to the diagnostic supervisor is basically that shown in Figure 5-3. Once a diagnostic program has been loaded and the diagnostic supervisor has been loaded and started, program control moves to the boot routine of the supervisor. This routine clears vector space, flags, mail boxes, and sets up the processor registers to a known state. The boot routine checks to determine whether the operator has typed a Control C and sets up a map of memory and I/O addresses creating P0 and P1 page tables. It then initializes the system control block and the process control block, and then calls the begin routine.

The begin routine changes the processor mode to kernel and calls the CLI (the command flag should be set). The CLI types out the prompt symbol, DS>, indicating that the supervisor is ready for commands. When the operator types in a command (e.g. START), a parser routine in the supervisor is activated to decode the command and call the requisite action routines, clear the command flag, and then call the dispatch routine.

The dispatch routine forms the heart of the supervisor. It begins by clearing the error count and setting the pass zero flag and then calls the initialization routine in the diagnostic program to be executed.

The initialization routine initializes the unit under test and sets up conditions in the CPU and on the SBI which are necessary to the diagnostic program. The initialization routine then questions the operator concerning the unit to be tested, creates a hardware parameter table (P Table), tests for end of pass, and returns control to the dispatch routine in the supervisor.

The dispatch routine then calls the first test. At the end of each test, control returns to the dispatch routine. At the end of the last test in the program (or the last test selected by the operator), the dispatch routine in the supervisor calls the initialization routine in the diagnostic program. This routine determines whether or not the end of the current pass has been reached. If the end of the current pass has not been reached, the first test routine in the dispatch section of the supervisor is called, beginning another test sequence. If the end of the pass has been reached, the program calls the end of pass routine in the supervisor.

The end of pass routine in the supervisor determines whether or not the last pass to be run has been completed. If so, the cleanup and summary routines in the diagnostic program are called, the CLI command mode is set, and control passes to the begin routine which calls the CLI. The CLI prints out the DS> prompt symbol and waits for operator input.

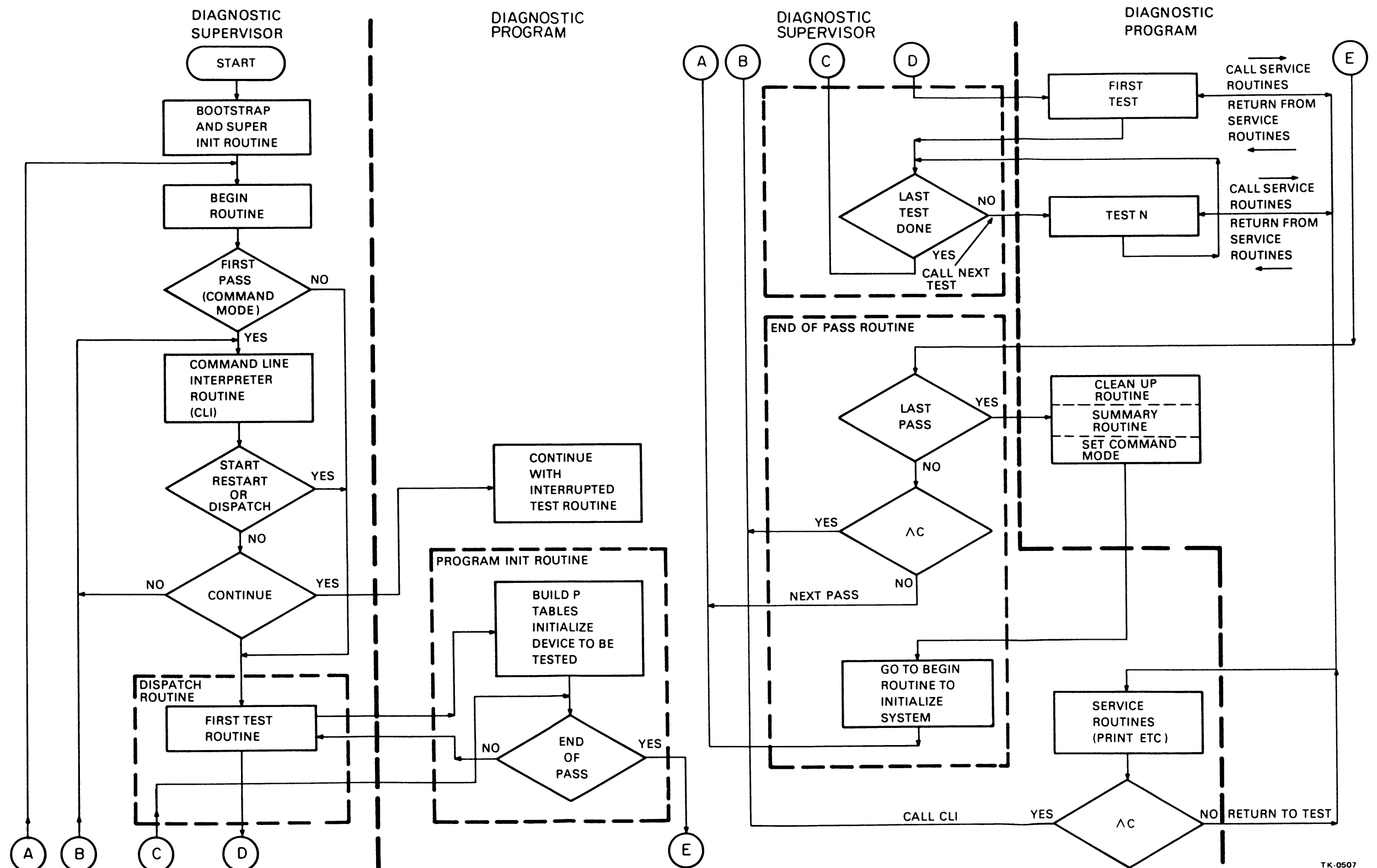


Figure 5-3 Diagnostic Program and Diagnostic Supervisor Interaction

If the last pass has not been completed, the end of pass routine checks to see whether the operator has typed control C. If the Control C flag is set, control returns to the CLI. Otherwise, the end of pass routine calls the begin routine in the supervisor to initialize the system and initiate the next pass of the diagnostic program.

Note that when the operator types Control C, he does not cause an interrupt routine to be called. The Control C merely sets a flag. The status of the flag is checked periodically when the tests in the diagnostic program call various service routines and at the end of a pass.

5.5 ANALYSIS OF A SAMPLE TEST: RH780 (MBA) TEST 3, SUBTEST 1

5.5.1 Listing Column Format Description

Figure 5-4 shows the program listing for the MBA RH780 diagnostic program (ESCAA), test 3, subtest 1. The sixth column from the left contains the relative address of each instruction. These numbers begin at 0 with the beginning of each program section. Note that the address offset of the program section containing Test 3 (3600₁₆), found in the link map, must be added to the relative address to find the virtual memory address of the instruction.

The seventh column from the left contains the listing line numbers. These numbers begin at 0 for each module of the program. Note that the line number increments for each line of the source module. The sixth column shows the program counter, containing the relative address. The relative address increases according to the amount of memory space required for the instructions and operands. Line numbers are present only for lines entered by the program developer. Macro expansions do not have line numbers.

The eighth column from the left contains labels used by the programmer as symbolic addresses.

The ninth column from the left contains instruction mnemonics and Macro calls. Note that the Macro calls themselves require no memory space (the relative address does not change), and that in the Macro expansion which follows, the line number is not incremented (line 317). At assembly time, the assembler program responds to the Macro calls, expanding the Macro according to the definition listed at the beginning of the file.

Column ten contains operands for those instructions contained in column nine; and it contains instruction mnemonics and parameters for the Macro expansions.

The eleventh column from the left contains operands from the Macro expansions.

Column five contains the op codes (hex) for the instructions contained in columns seven and eight.

Columns one through four contain the hexadecimal code for the operands specified in columns ten and eleven. Columns two and four contain operand specifiers. Columns one and three contain operand specifier extensions. Numbers followed by an apostrophe (e.g., 00000000') are the machine code for symbolic operands. They are modified by the linker at link time. (MARS is a one pass assembler. Forward references, with the exception of branches within P sections, and global symbols cannot be resolved until link time.)

The twelfth column contains comments describing the functions of the instructions. Each comment is preceded by a semicolon.

5.5.2 Analysis Of Typical Lines

Line 311 -- The BISL instruction sets bits in the destination according to the mask provided. #PGM.INIT is the symbol for the mask. Its value (00000001) can be found in the symbol table at the end of the module. CR is the symbol for the relative address (offset from the MBA base register) of the control register of the MBA under test. Its value (00000004) is also listed in the symbol table. This value is added to the contents of R2, the base address of the MBA under test, to produce the physical address of the control register. The instruction thus sets bit zero of the control register. The comment, INIT, indicates the function that setting bit zero performs.

Line 317 -- \$ERRHARDS, in line 317, is a Macro call. The symbols that follow it are arguments to be used in the call. The five lines that follow line 317 show the expansion of the Macro. These instructions push the arguments on the stack and call the DS\$ERRHARD subroutine in the supervisor, which sets the error flag and prints an error message based on the stored arguments.

5.6 RH780 (MBA) DIAGNOSTIC SAMPLE SUBTEST (Direct I/O)

5.6.1 RH780 Diagnostic Detailed Flow

Each test in a given diagnostic program relies on subroutines provided by the diagnostic supervisor. The diagnostic program thus depends on the supervisor for services as well as initialization and test sequencing functions. The operator should be able to follow references and subroutine calls back and forth between the diagnostic program being run and the supervisor in order to use the listings.

The general strategy used throughout the diagnostic programs involves writing and then reading back data directly (with MOVE instructions) in order to exercise the logic circuits or device functions under test. Data retrieved is compared with data expected. If the comparison indicates a failure, an error routine takes appropriate action and sends a message to the operator. Subroutine 1 of test 3 of the MBA diagnostic is representative of this strategy. This subtest determines whether the control register of the MBA under test can be cleared after each bit in the register has been set.

When the diagnostic supervisor calls test 3 of the MBA diagnostic, the test initialization code moves the base address of the MBA under test to general register 2. This register is then used to index specific MBA registers. The ERRPREP Macro then stores information concerning test 3 in a buffer area for use in error messages.

Subtest 1 begins with a call to the DS\$BGNSUB entry point in the supervisor, as shown in Figure 5-5. In order to find this entry point, look in the global symbol table in the program link map (Figure 5-6). DS\$BGNSUB equals 00010030, an address in the supervisor. Note that the first two characters of the symbol (DS) indicate that the symbol points into the diagnostic supervisor. The global symbol table in the link map for the supervisor shows that the entry module (ESSA11) defines the symbol (contains the code for the entry point) (Figure 5-7). The names of the supervisor modules suggest their functions (e.g., entry, loop, print).

The DS\$BGNSUB entry point contains only one instruction, a jump to RBGNSUB, as shown in Figure 5-8. This subroutine is in the loop module of the supervisor (Figure 5-9). RBGNSUB checks the subtest sequence for correct order. A discrepancy causes the subroutine to call a print routine, which displays an error message, and then to return to the CLI. If the subtest sequence is correct, the RBGNSUB subroutine calls the KB-CHECK routine to check for Control C. If the operator has typed Control C, control returns to the CLI. Otherwise, control returns to subtest 1 which, at this point, begins testing the MBA logic.

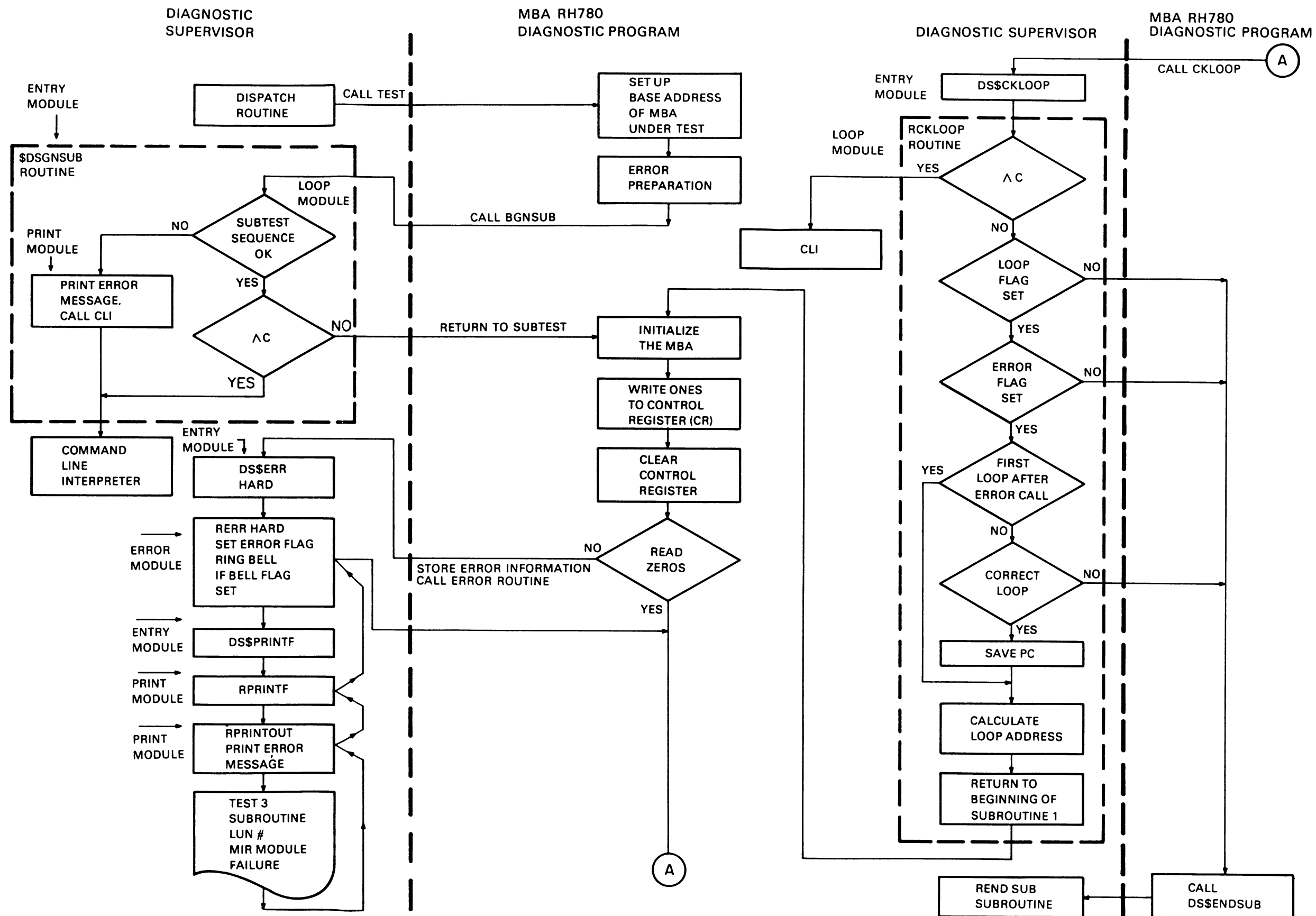


Figure 5-5 RH780 (MBA)
Diagnostic Program Test 3,
Subtest 1, Flowchart

MIR_MDP_MCP_MSI	0000066E-R	MIR_MSI	000006AB-R	MIR_MSI_MCP	000006D2-R
MIR_MSI_MCP_MDP	00000704-R	MIR_MSI_MCP	00000741-R	MIR_MSI_MDP_MCP	00000773-R
MSI	000009A8-R	MSI_MCP	00000A59-R	MSI_MCP_MIR	00000A80-R
MSI_MCP_MIR_MDP	00000AB2-R	MSI_MIR	000009C3-R	MSI_MIR_MCP	000009EA-R
MSI_MIR_MCP_MDP	00000A1C-R	MSR_SNAP	000002F0-R	NODRIVE	000002E0-R
NO_UNITS	000002B3-R	NUMBER_BUFFER	00000540-R	PTBASE	000002B4-R
QST_INIT1	00001953-R	REC_MSG	000018F1-R	REG_NAME	00000544-R
REG_NO	00000548-R	REG_STRING	0000054C-R	REPORT_BUFFER	00000340-R
RH0	0000028D-R	RH1	00000291-R	RH2	00000295-R
RH3	00000299-R	RH4	0000029D-R	RH5	000002A1-R
RH6	000002A5-R	RH7	000002A9-R	RHRCR_MSG	00001933-R
RHCR_MSG	0000191D-R	RHCSR_MSG	00001915-R	RHDR_MSG	0000193B-R
RHMAPR_MSG	00001942-R	RHSP_MSG	00001924-R	RHVAR_MSG	0000192B-R
RH_ADR_TABLE	0000028D-R	RH_RRLVL	000002AE-R	RH_CUR_ADR	00000288-R
RH_TRLVL	000002AD-R	SA0_MSG	000018CE-R	SA1_MSG	000018D9-R
SFT_P_TABLE	00001AB5-R	SUFFIX_PTR	00000554-R	TEMP	0000055C-R
TIMOUT_EVT_FLAG	000002E6-R	TIMOUT_RET_PC	000002E7-R	UNEXPECTED	000018E4-R
WAIT_TIME	000002EC-R				
2	<\$HEADER>:	PAGE	9	00000200	00000281 00000282
3	<_LAST>:	PAGE	9	00000B60	00000B60 00000000
4	<\$STCNT>:	LONG	2	00000284	00000284 00000000
5	<\$ABSS>:	BYTE	0	00000000	00000000 00000000
GLOBAL SYMBOLS DEFINED:-					
DSSABORT	00010020	D\$ASKADR	00010090	D\$ASKDATA	00010080
D\$ASKLGCL	00010098	D\$ASKSTR	000100A0	D\$ASKVLD	00010088
<u>D\$BGNSUB</u>	<u>00010030</u>	D\$BREAK	00010058	D\$SCANWAIT	00010070
D\$CHANNEL	00010180	D\$CKLOOP	00010040	D\$CLRVEC	00010168
D\$CNTRLC	00010078	D\$CVTREG	000100B0	D\$ELOGOFF	00010108
D\$ELOGON	00010100	D\$ENDPASS	00010010	D\$ENDSUB	00010038
D\$ERRDEV	000100C8	D\$ERRHARD	000100D0	D\$ERRSOFT	000100D8
D\$ERRSYS	000100C0	D\$ESCAPE	00010050	D\$GETBUF	00010120
D\$GETMEM	00010130	D\$GPHARD	00010018	D\$INITSCB	00010170
D\$INLOOP	00010048	D\$MMOFF	00010158	D\$MMON	00010150
D\$MOVPHY	00010148	D\$MOVVRT	00010140	D\$PARSE	000100B8
D\$PRINTB	000100E0	D\$PRINTF	000100F0	D\$PRINTS	000100F8
D\$PRINTX	000100E8	D\$RELBUF	00010128	D\$RELMEM	00010138
D\$SETIPL	00010178	D\$SETMAP	00010188	D\$SETVEC	00010160
D\$SHOCHAN	00010190	D\$SUMMARY	00010028	D\$WAITMS	00010060
D\$WAITUS	00010068	SYS\$ALLOC	00010238	SYS\$ASSIGN	00010250
SYS\$BINTIM	00010258	SYS\$CANCEL	00010260	SYS\$CANTIM	00010268
SYS\$CLREF	00010298	SYS\$DALLOC	000102D8	SYS\$DASSGN	000102E0
SYS\$GETCHN	000104C8	SYS\$GETTIM	00010378	SYS\$QIO	000103C8
SYS\$QIOW	00010200	SYS\$READDEF	000103D0	SYS\$SETEF	00010400
SYS\$SETIMR	00010420	SYS\$SETPRT	00010430	SYS\$WAITFR	00010478
SYS\$WFLAND	00010488	SYS\$WFLOR	00010490		
6	<DISPATCH>:	LONG	2	00002670	00002670 00000000
7	<DISPATCH_X>:	LONG	2	00002850	00002867 00000018

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Figure 5-6 DS\$BGNSUB Listed
in the Symbol Table in the
ESCAA Link Map

SYMBOL	VALUE	DEFINED BY	REFERENCED BY ...
-----	-----	-----	-----
DRA\$UCB2	0001B4E8-R	IOBASE_ESSAA43	DEVICE_ESSAA9
DRA\$UCB3	0001B588-R	IOBASE_ESSAA43	DEVICE_ESSAA9
DSSAA_BPTADDR	00012FD0-R	DEBUG_ESSAA8	ERROR_ESSAA12
DSSABORT	00010020-R	ENTRY_ESSAA11	FRKCTL_ESSAA41
			PARAM_ESSAA19
			LOOP
			IOSRAM_ESSAA46
			GIOREQ_ESSAA51
			SCB_ESSAA23
			LODMAP_ESSAA47
			SCB_ESSAA23
DSSABORTWAIT	00010070-R	ENTRY_ESSAA11	
DSSAB_BPTINST	00012FC0-R	DEBUG_ESSAA8	
DSSAQ_SSEND	000107FF-R	ENTRY_ESSAA11	LOOP
DSSAQ_SYSSRV	00010200-R	ENTRY_ESSAA11	
DSSASKADR	00010090-R	ENTRY_ESSAA11	MEMMGT_ESSAA18
DSSASKDATA	00010080-R	ENTRY_ESSAA11	
DSSASKLGCL	00010098-R	ENTRY_ESSAA11	
DSSASKSTR	000100A0-R	ENTRY_ESSAA11	
DSSASKVLD	00010088-R	ENTRY_ESSAA11	
DSSAX_SOFTPCB	0001E700-R	KERNEL_ESSAA15	
			START_ESSAA25
			DEVICE_ESSAA9
			ASSIGN_ESSAA36
			CHMK_ESSAA4
			IOPOST_ESSAA52
			APT
			ASTDEL_ESSAA1
			DASSGN_ESSAA38
			CANCEL_ESSAA37
			DEVALC_ESSAA40
DSSA_PRGBGN	00000200	KERNEL_ESSAA15	
DSSBGNSUB	00010030-R	ENTRY_ESSAA11	
DSSBREAK	00010058-R	ENTRY_ESSAA11	
DSSCANWAIT	00010070-R	ENTRY_ESSAA11	
DSSCHANNEL	00010180-R	ENTRY_ESSAA11	
DSSCKLOOP	00010040-R	ENTRY_ESSAA11	
DSSCLI	000138B0-R	CLI_ESSAA5	
DSSCLRVEC	00010168-R	ENTRY_ESSAA11	
			DEBUG_ESSAA8
			CHANNEL_ESSAA3
			START_ESSAA25
			DISPAT_ESSAA10
			CHANNEL_ESSAA3
			SCB_ESSAA23
DSSCNTRLC	00010078-R	ENTRY_ESSAA11	
DSSCVTREG	000100B0-R	ENTRY_ESSAA11	
			SCB_ESSAA23
			DEVICE_ESSAA9
			UBAINT_ESSAA55
			MEMMGT_ESSAA18
DSSDOSUMMARY	00010028-R	ENTRY_ESSAA11	
DSSENDPASS	00010010-R	ENTRY_ESSAA11	
DSSENDSUB	00010038-R	ENTRY_ESSAA11	
DSSENTRY	00016621-R	VERSION_ESSAA33	
DSSERRDEV	000100C8-R	ENTRY_ESSAA11	
DSSERRHARD	000100D0-R	ENTRY_ESSAA11	
DSSERRSOFT	000100D8-R	ENTRY_ESSAA11	
DSSERRSYS	000100C0-R	ENTRY_ESSAA11	
DSSESCAPE	00010050-R	ENTRY_ESSAA11	
DSSGA_BREAKVEC	00013588-R	SCB_ESSAA23	
DSSGA_BUFPTR	0001318C-R	KERNEL_ESSAA15	
DSSGA_CHKLPCC	00013160-R	KERNEL_ESSAA15	
DSSGA_CHMKVEC	00013584-R	SCB_ESSAA23	
DSSGA_LASTADR	00013168-R	KERNEL_ESSAA15	
DSSGA_LOOPADR	00013164-R	KERNEL_ESSAA15	
DSSGA_PBASE	00013568-R	PARAM_ESSAA19	
DSSGA_TBITVEC	0001358C-R	SCB_ESSAA23	
DSSGB_BYTEBUF	00013190-R	KERNEL_ESSAA15	
DSSGETADDRESS	00010090-R	ENTRY_ESSAA11	
DSSGETBUF	00010120-R	ENTRY_ESSAA11	
DSSGETDATA	00010080-R	ENTRY_ESSAA11	
DSSGETLOGICAL	00010098-R	ENTRY_ESSAA11	
DSSGETSTRING	000100A0-R	ENTRY_ESSAA11	
DSSGETVIELD	00010088-R	ENTRY_ESSAA11	
DSSGL_BUFENT	00012E00-R	BUFFER_ESSAA2	
DSSGL_BUFLEN	00013188-R	KERNEL_ESSAA15	
			DISPAT_ESSAA10
			CHMK_ESSAA4
			MEMMGT_ESSAA18
			LOOP
			DEVICE_ESSAA9
			START_ESSAA25
			CONSOLE
			PARAM_ESSAA19
			MEMMGT_ESSAA18
			PARAM_ESSAA19
			PARAM_ESSAA19
			PARAM_ESSAA19
			PARAM_ESSAA19
			PARAM_ESSAA19
			KERNEL_ESSAA15
			PARAM_ESSAA19
			MEMMGT_ESSAA18
			PRINT

Figure 5-7 DS\$BGNSUB Listed
in the Symbol Table in the
Supervisor Link Map

ZZ-ESSAA-4.04
ENTRY_ESSAA11
06-08

ENTRY POINTS TO THE DIAGNOSTIC SUPERVISOR,
DIAGNOSTIC AND STARLET SERVICE ENTRY VECTORS, 22
ENTRY POINTS TO THE DIAGNOSTIC SUPERVISOR.

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Sequence 525
Page 6
(4)

Address	Hex	Label	Comment
0030	171	;	
0030	172	; 4.2.1	PROGRAM CONTROL SERVICES.
0030	173	:-	
00000000*EF	17	0030 174 .ALIGN QUAD	
		0030 175 DS\$BGNSUB::	; BEGIN SUBTEST ENTRY POINT.
		0030 176 .WORD	; ENTRY MASK
		0032 177 JMP	RBGNSUB
		0038 178	
00000000*EF	17	0038 179 .ALIGN QUAD	
		0038 180 DS\$ENDSUB::	; END SUBTEST ENTRY POINT.
		0038 181 .WORD	; ENTRY MASK
		003A 182 JMP	RENDSUB
		0040 183	
		0040 184 .ALIGN QUAD	
00000000*EF	17	0040 185 DS\$CKLOOP::	; CHECK LOOP ENRTY POINT.
		0040 186 .WORD	; ENTRY MASK
		0042 187 JMP	RCKLOOP
		0048 188	
		0048 189 .ALIGN QUAD	
00000000*EF	17	0048 190 DS\$INLOOP::	; IN LOOP ENTRY POINT.
		0048 191 .WORD	; ENTRY MASK
		004A 192 JMP	RINLOOP
		0050 193	
		0050 194 .ALIGN QUAD	
00000000*EF	17	0050 195 DS\$ESCAPE::	; ESCAPE ENTRY POINT.
		0050 196 .WORD	; ENTRY MASK
		0052 197 JMP	RESCAPE
		0058 198	
		0058 199 .ALIGN QUAD	
0000	0058	200 DS\$BREAK::	; BREAK FOR DYNAMIC SERVICES.
FFA3	30	0058 201 .WORD	; SAVE NO REGISTERS
04	005A	202 RSBW	KB_CHECK
	005D	203 RET	; CHECK KEYBOARD
	005E	204	
	005E	205 .ALIGN QUAD	
0000	0060	206 DS\$WAITMS::	; WAIT MILLISECONDS ENTRY POINT.
00000000*EF	17	0060 207 .WORD	; ENTRY MASK
		0062 208 JMP	DSX\$WAITMS
		0068 209	
		0068 210 .ALIGN QUAD	
0000	0068	211 DS\$WAITUS::	; WAIT MICROSECONDS ENTRY POINT.
00000000*EF	17	0068 212 .WORD	; ENTRY MASK
		006A 213 JMP	DSX\$WAITUS
		0070 214	
		0070 215 .ALIGN QUAD	
		0070 216 DS\$SCANWAIT::	
0000	0070	217 DS\$ABORTWAIT::	; CANCEL WAIT ENTRY POINT.
00000000*EF	17	0070 218 .WORD	; ENTRY MASK
		0072 219 JMP	DSX\$SCANWAIT
		0078 220	
		0078 221 .ALIGN QUAD	
0000	0078	222 DS\$CNTRLC::	; *X10078
000000002*EF	17	0078 223 .VECTOR	DSX\$CNTRLC
		007A 224 JMP	DSX\$CNTRLC+2

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Figure 5-8 DS\$BGNSUB
Entry Point

SYMBOL	VALUE	DEFINED BY	REFERENCED BY ...
-----	-----	-----	-----
PREADVBLK	00017170-R	CONSOLE	QIO_ESSAA22
PRTSC_UW	00000004	SYSVECTOR	DEBUG_ESSAA8
RBGNSUB	0001525A-R	LOOP	ENTRY_ESSAA11
RBREAK	000150F6-R	PARAM_ESSAA19	
RCKLOOP	00015394-R	LOOP	ENTRY_ESSAA11
RCTRLC	0001505B-R	KERNEL_ESSAA15	
READVBLK	00017170-R	CONSOLE	QIO_ESSAA22
RENDSUB	000152CE-R	LOOP	ENTRY_ESSAA11
REKRDEV	0001496F-R	ERROR_ESSAA12	ENTRY_ESSAA11
RERRHARD	00014859-R	ERROR_ESSAA12	ENTRY_ESSAA11
RERRSOFT	00014843-R	ERROR_ESSAA12	ENTRY_ESSAA11
RERRSYS	0001498B-R	ERROR_ESSAA12	ENTRY_ESSAA11
RESCAPE	0001524C-R	LOOP	ENTRY_ESSAA11
RGETADDRESS	000155FE-R	PARAM_ESSAA19	ENTRY_ESSAA11
RGETDATA	0001547C-R	PARAM_ESSAA19	ENTRY_ESSAA11
RGETLOGICAL	000156A2-R	PARAM_ESSAA19	ENTRY_ESSAA11
RGETSTRING	00015779-R	PARAM_ESSAA19	ENTRY_ESSAA11
RGETVFIELD	00015544-R	PARAM_ESSAA19	ENTRY_ESSAA11
RGPARD	000158B8-R	PARAM_ESSAA19	ENTRY_ESSAA11
RINLOOP	000153BC-R	LOOP	ENTRY_ESSAA11
RPTADR	00017C61-R	MEMMGT_ESSAA18	QIOFDT_ESSAA50
RTYPEMSG	00015DA6-R	PRINT	CLI_ESSAA5
			DISPAT_ESSAA10
			START_ESSAA25
			PARAM_ESSAA19
SCB_BASE	0001E800-R	KERNEL_ESSAA15	SCB_ESSAA23
SCB_IMAGE	00016800-R	SCB_ESSAA23	KERNEL_ESSAA15
SCH\$ASTDEL	000189F4-R	ASTDEL_ESSAA1	SCR_ESSAA23
SCH\$NEWLVL	00018A13-R	ASTDEL_ESSAA1	CHMK_ESSAA4
SCH\$QAST	00018AEA-R	ASTDEL_ESSAA1	CLOCK_ESSAA6
SEC_TICK	00000064	CLOCK_ESSAA6	KERNEL_ESSAA15
SGN\$GL_IRPCNT	00000000	KERNEL_ESSAA15	MEMMGT_ESSAA18
SGN\$GL_IRPCNT	0001C3E0-R	KERNEL_ESSAA15	MEMMGT_ESSAA18
SGN\$GL_NPAGEDYN	0001C3CC-R	KERNEL_ESSAA15	MEMMGT_ESSAA18
SS\$_ABORT	0000002C	SYSVECTOR	TMDRVR_ESSAA57
SS\$_ACCVIO	0000000C	SYSVECTOR	ACPFDT_ESSAA35
SS\$_BADPARAM	00000014	SYSVECTOR	ACPFDT_ESSAA35
SS\$_BREAK	00000014	SYSVECTOR	DEBUG_ESSAA8
SS\$_BUFRYTAI	0000030C	SYSVECTOR	DMDRVR_ESSAA53
SS\$_CANCEL	00000030	SYSVECTOR	CANCEL_ESSAA37
SS\$_CMODSUPR	0000001C	SYSVECTOR	DEBUG_ESSAA8
SS\$_CMODUSER	00000024	SYSVECTOR	DEBUG_ESSAA8
SS\$_COMPAT	0000002C	SYSVECTOR	DEBUG_ESSAA8
SS\$_CONTINUE	00000001	SYSVECTOR	DEBUG_ESSAA8
SS\$_CONTROL	00000051	SYSVECTOR	CONSOLE
SS\$_CTRLERR	00000054	SYSVECTOR	DBDRVR_ESSAA39
			TMDRVR_ESSAA57
			DMODRVR_ESSAA53
			DRDRVR_ESSAA54
SS\$_DATACHECK	0000005C	SYSVECTOR	DBDRVR_ESSAA39
			DMODRVR_ESSAA53
			DRDRVR_ESSAA54
			TMDRVR_ESSAA57
SS\$_DATAOVERUN	00000038	SYSVECTOR	TMDRVR_ESSAA57
SS\$_DEVFOREIGN	00000064	SYSVECTOR	ACPFDT_ESSAA35
SS\$_DEVNOTMOUNT	0000007C	SYSVECTOR	ACPFDT_ESSAA35
SS\$_DEVOFFLINE	00000084	SYSVECTOR	QIOREQ_ESSAA51
SS\$_DRVERR	0000008C	SYSVECTOR	DBDRVR_ESSAA39
			DMODRVR_ESSAA53
			DRDRVR_ESSAA54
			TMDRVR_ESSAA57
SS\$_ENDOFFILE	00000070	SYSVECTOR	ACPFDT_ESSAA35
SS\$_ENDOTAPE	00000078	SYSVECTOR	TMDRVR_ESSAA57
			IOPOST_ESSAA52
			TMDRVR_ESSAA57

Figure 5-9 RBGNSUB Listed in
the Symbol Table in the
Diagnostic Supervisor Link Map

Subtest 1 initializes the MBA under test by writing a one to bit zero of the control register, the initialization bit. The subtest then writes ones to the control register, writes zeros, and then reads the register. If zeros are not returned from the control register, the subtest calls the DS\$ERRHARD entry point in the supervisor. The DS\$ERRHARD code is in the supervisor entry module, ESSAAll (see the supervisor link map). DS\$ERRHARD causes a jump to RERRHARD, which is located in the error module of the supervisor. RERRHARD sets the error flag, rings the bell if the bell on error flag is set, and calls the DS\$PRINTF entry point. Like the other DS\$ entry points, this one is located in the entry module and contains only a jump instruction. The jump transfers control to the RPRINTF routine in the print module (see the supervisor link map). RPRINTF, in turn, calls the RPRINTOUT routine, also in the print module. This routine prints out a message on the operator's terminal indicating the test and subtest numbers, the logical unit number (LUN) under test, and the failing module name (MIR). RPRINTOUT returns control to RPRINTF, which returns control to RERRHARD, which returns control to ESCAA test 3, subtest 1.

At this point, the testing and error reporting portions of subtest 1 have been completed. The subtest then calls DS\$CKLOOP (in the control module of the supervisor). This entry point causes a jump to the RCKLOOP subroutine, which is located in the loop module. Unless the loop and error flags are both set, control returns to the subtest, which in turn calls DS\$ENDSUB in the supervisor to terminate subtest 1 and start the next subtest.

If the loop and error flags are both set, the loop address is calculated and the RCLKLOOP routine causes a jump back to the beginning of subtest 1, at label 10\$. Note that if the loop is the first loop after the error call, the test and subtest numbers are checked. If one of these numbers is wrong, control returns to the subtest as if the loop flag were not set. After the first loop, the subtest will be repeated continually.

5.6.2 RH780 Diagnostic Sample Error Message

The error messages generated by the RH780 diagnostic vary, depending on the type of error detected and the type of the failing test. However, in all cases the error message will identify the failing module (or bus signal) and the nature of the failure. Expected and received data are printed when meaningful. For example, if bit 2 (IE) of the MBA control register is set, the error message printed will look like that shown in Figure 5-10.

```

*****MAINDEC ZZ-ESCAA-5.0 RH780 DIAGNOSTIC-5.0*****
PASS 1 TEST 3 SUBTEST 1 ERROR 1 1-JUN-1978 10:53:30.70
HARE ERROR WHILE TESTING MBA: FAILING MODULE: MIR(M8276)

(RHCR)=00000004
EXPECTED: ZERO
RECEIVED: IE
XOR:      IE

```

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Figure 5-10 ESRCA Sample Error Listing

Use the test, subtest, and error number to look up the relevant code in the program listing. Notice that test 3, subtest 1, error 1 is the portion of the program discussed in the previous paragraph. The program sets the maintenance bit in the control register. It then writes ones to the control register, clears the register, and reads the register. Since bit 2 is stuck at one, the received data and the expected data do not match.

After listing the failure, the program continues with the succeeding tests. The operator may, at this point, shut down the computer to change the MIR board as directed, or use the diagnostic supervisor commands to set up a scope loop and monitor the failure more closely.

5.7 RPØX/DCL REPAIR DIAGNOSTIC (DIRECT I/O), SAMPLE SUBTEST

5.7.1 Detailed Flow

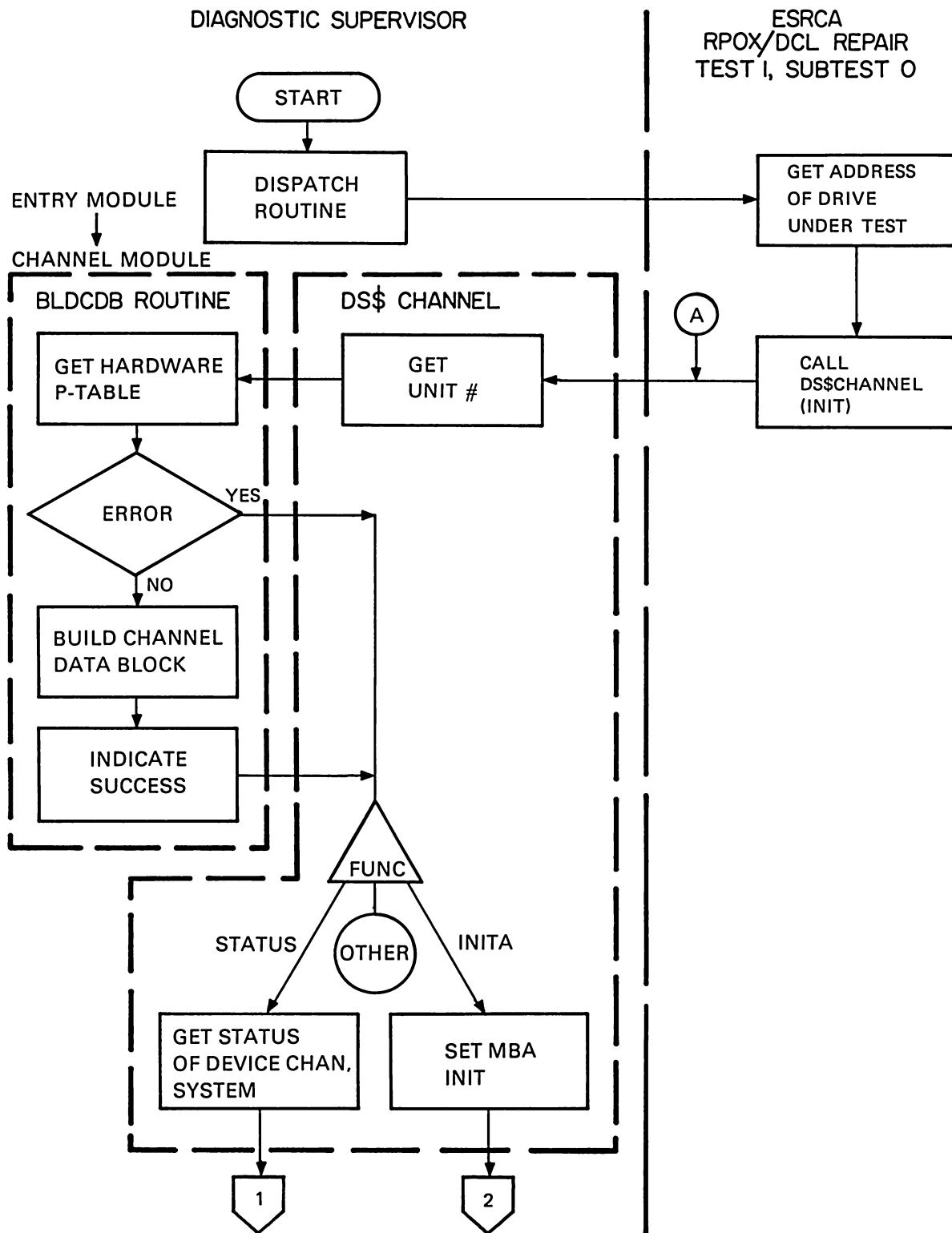
The RPØX/DCL Repair Diagnostic (ESRCA) is representative of the peripheral diagnostic programs that use direct I/O. Like the cluster diagnostic programs, the RPØX/DCL repair diagnostic accesses registers on the unit under test directly, with move and bit set instructions and the like. However, the RPØX/DCL repair diagnostic relies more heavily than the MBA diagnostic on services provided by the diagnostic supervisor. In particular, it uses the channel services of the supervisor to perform such functions as initializing a channel, aborting a function, enabling and disabling interrupts, setting map registers, defeating parity, and determining adapter and error status.

For example, when the dispatch routine in the supervisor calls the first test in the RPØX/DCL repair diagnostic, the test routine gets the address of the device under test and then, passing a list of arguments, calls for channel services through the DS\$CHANNEL entry point in the supervisor. Figure 5-11 shows the code for test 1, subtest 0, errors 1-3. Figure 5-12 shows the subtest flow. DS\$CHANNEL calls DSX\$CHANNEL, which in turn, calls the BLDCDB subroutine, which builds a channel data block containing the

		00FE	DATA_001:			
	00000000	00FE			.LONG 0	; TEST ARGUMENT TABLE TERMINATOR
		0102	TEST_001::			
52	0000'CF	00	0104	106 105:	MOVL	W^BASE_ADDRESS,R2 ; ENTRY MASK ; GET DRIVE'S ADDRESS
	00000000'EF	7F	0109			
	00	DD	010F			
	00	DD	0111			
	00000000'EF	DD	0113			
00000000'9F	04	FB	0119			
53	62	DD	0120	108	MOVL	RPCS1(R2),R3 ; GET CONTROL/STATUS
			0123	109	SDS_CHANNEL_S	DRIVE,#CHCS_STATUS,,CH_STATUS
	00000000'EF	7F	0123			
	00	DD	0129			
	07	DD	012B			
	00000000'EF	DD	012D			
00000000'9F	04	FB	0133			
00000000'EF	15	E1	013A	110	BBC	#CHSSV_MBACPE,CH_STATUS,20\$; CHECK FOR CONTROL BUS
	2B		0141			
			0142	111		; PARITY ERROR
	00	DD	0142			
	FED0 CF	DF	0144			
	0000'CF	DD	0148			
	01	DD	014C			
			014E			
00000000'9F	04	FB	014E		;;; TEST 1, SUBTEST 0, ERROR 1	
	00000000'EF	DD	0155			
00000000'9F	01	FB	015B			
00000000'9F	9F AF	FA	0162			
	018B	31	016A			
			016D			
00000000'EF	11	E1	016D	117 20\$:	BBC	#CHSSV_MBANED,CH_STATUS,25\$; CHECK FOR NON-EXIST. DRIVE
	2C		0174			
			0175	118	SDS_ERRHARD_S	W^DRIVE,W^MSG_NED
	00	DD	0175			
	FEBF CF	DF	0177			
	0000'CF	DD	017B			
	02	DD	017F			
			0181		;;; TEST 1, SUBTEST 0, ERROR 2	
00000000'9F	04	FB	0181			
			0188	119	SDS_SHOCHAN_S	DRIVE
	00000000'EF	DD	0188			
00000000'9F	01	FB	018E			
			0195	120	SDS_CKLOOP	10\$
00000000'9F	FF6B CF	FA	0195			
			019E	121	SDS_EXIT	TEST
	0157	31	019E			TEST_001_X ; 'EXIT TEST 1

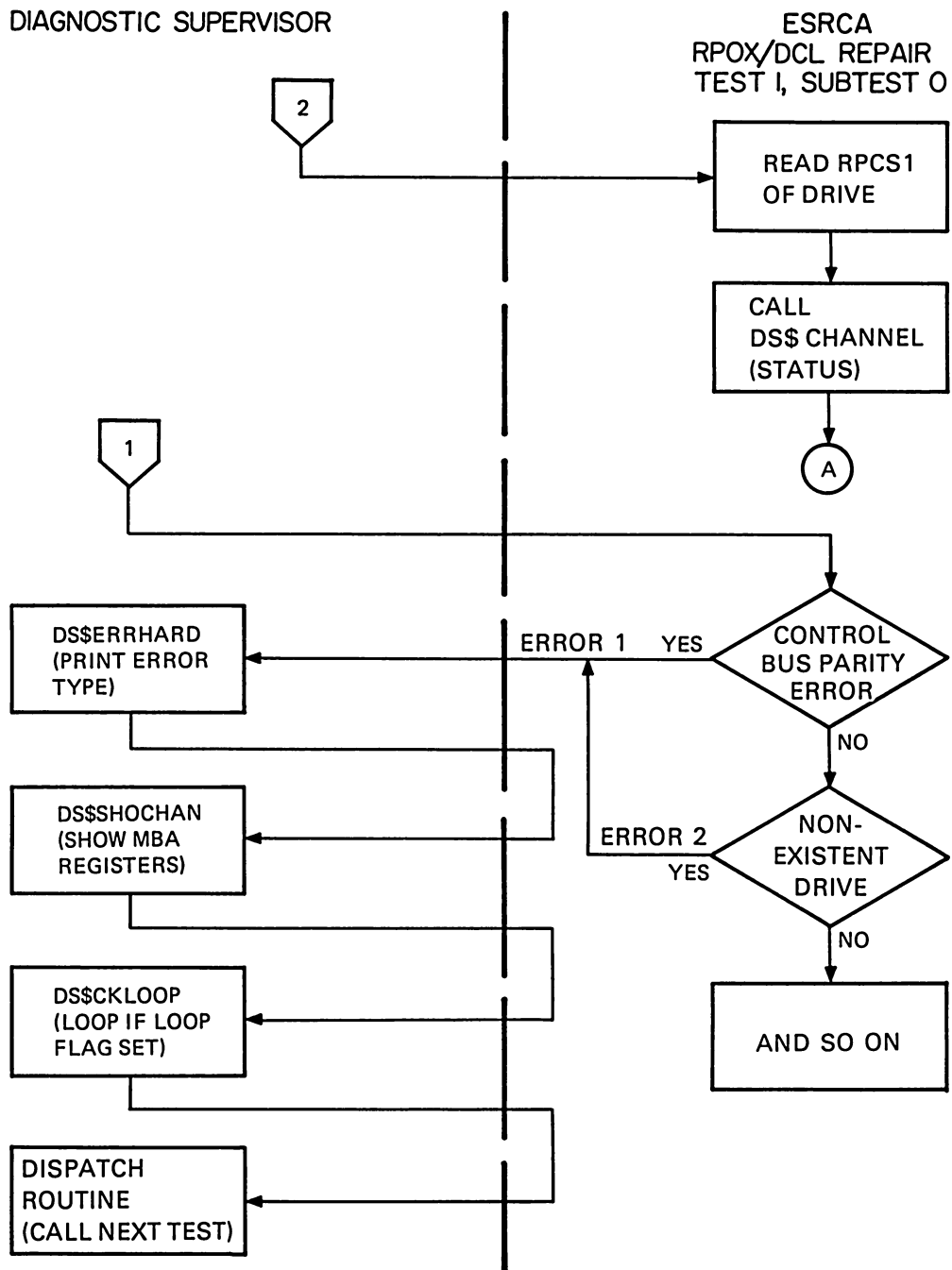
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Figure 5-11 ESRCA RP0X/DCL
Test 1, Subtest 0,
Program Listing



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Figure 5-12 ESRCA RPOX/DCL Repair Diagnostic Test 1, Subtest 0, Flowchart (Sheet 1 of 2)



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Figure 5-12 ESRCA RPØX/DCL Repair Diagnostic Test 1, Subtest Ø, Flowchart (Sheet 2 of 2)

P-Table address, and the adapter address; clears the flag word; and determines whether the channel is an MBA or a UBA. When control returns to the DSX\$CHANNEL routine, the function argument passed from the calling program (ESRCA) is evaluated, activating one of several function subroutines. In this case, the INITA subroutine sets the initialization bit in the MBA control register.

Control then returns to the calling program (ESRCA), which reads the RPCS1 (control status) register of the unit under test with a MOVE instruction (direct I/O). The test routine then calls DS\$CHANNEL again, this time passing a different function argument (CHC\$ STATUS). The DSX\$CHANNEL routine is executed again, activating the CHC\$ STATUS subroutine which stores the unit and adapter status in the location labeled CH STATUS.

Then when control returns from the DSX\$CHANNEL routine to the test routine, the data in location CH STATUS is compared, bit by bit, with expected data patterns. If an error is detected, the test routine calls a series of supervisor routines (DS\$ERRHARD, DS\$SHOCHAN, DS\$CKLOOP, and DISPATCH) to print out error information, loop if the loop flag is set, and return to the dispatch routine if the loop flag is not set.

5.7.2 RP0X/DCL Repair Diagnostic Sample Error Message

Test 1, subtest 0, error 1 of the RP0X/DCL diagnostic identifies control bus parity failures on the Massbus (Figure 5-11). When the program detects this failure, the error message identifies the failure by test, subtest, error, failing unit, and error type. In addition, the message includes an MBA channel status dump, showing the contents of the pertinent registers, as shown in Figure 5-13.

Bit 17 of the status register is set, indicating the Massbus control parity error.

Other error message formats display expected and received data and the contents of relevant registers in the RP0X/DCL, depending on the error and the failing test.

5.8 DISK RELIABILITY DIAGNOSTIC (QUEUE I/O), SAMPLE SUBTEST

5.8.1 Detailed Flow

The Disk Reliability Diagnostic program (ESRAA) is representative of the queue I/O diagnostics. Instead of performing move instructions to read and write peripheral device registers directly (as the MBA diagnostic does), the program builds an argument list containing device and transfer parameters and pointing to the data to be transferred and the function to be performed. The program then calls the queue I/O services of VMS or the diagnostic supervisor. In this way, the program transfers information to and from the peripheral device under test without requiring exclusive use of the device, the channel, or the computer system. Figure 5-14 shows the listing for ESRAA test 1, subtest 0, error 12, the first of the data transfer tests. Figure 5-15 shows the program flow for the same routine.

** PROGRAM: ZZ-ESRCA RP0X/DCL DIAGNOSTIC, REV 4.1, 46 TESTS.

TEST 1: QUALIFICATION TESTS

***** ZZ-ESRCA RP0X/DCL DIAGNOSTIC - 4.1 *****

PASS 1 TEST 1 SUBTEST 0 ERROR 2 10-MAR-1978 08:26:20.26

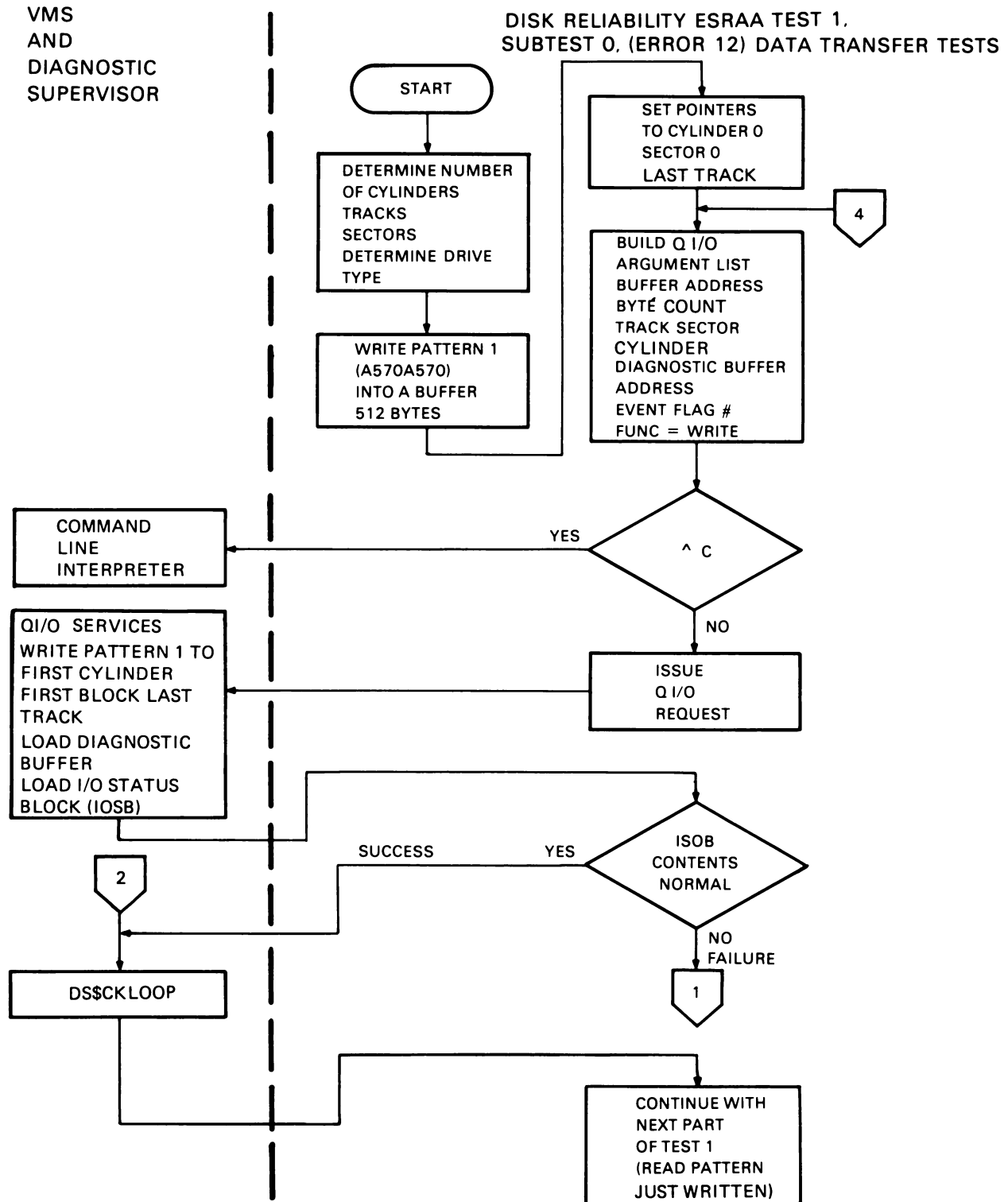
DEVICE FATAL WHILE TESTING DBA0: CONTROL BUS PARITY ERROR DETECTED

MBA CHANNEL STATUS DUMP

MBA_CSR:[20010000]	00000020(X);	
MBA_CR:[20010004]	00000000(X);	
MBA_SR:[20010008]	00020000(X);	MCPE
MBA_VAR:[2001000C]	00000200(X);	
MBA_MAP(80):	00000000(X);	
MBA_BCNT:[20010010]	00000000(X);	

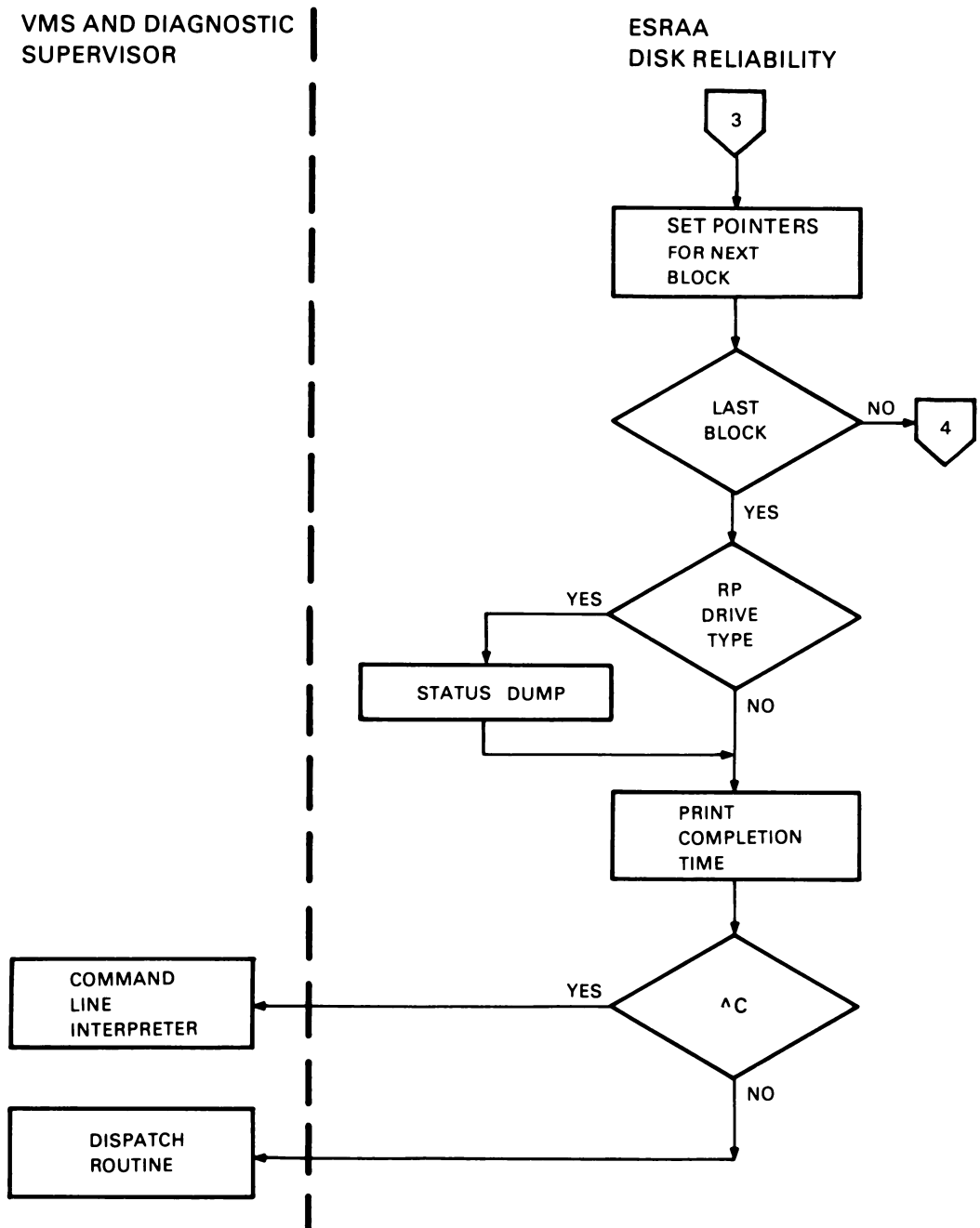
TK-1265

Figure 5-13 ESRCA Sample Error Message



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Figure 5-15 ESRAA Test 1, Subtest 0, Error 12 Flowchart
(Sheet 1 of 3)



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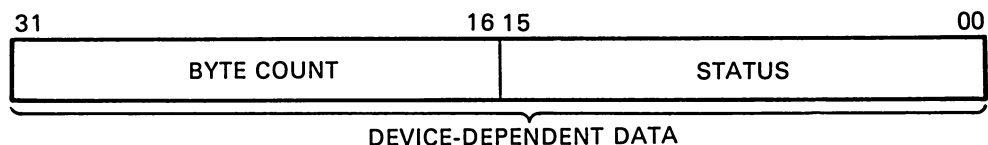
Figure 5-15 ESRAA Test 1, Subtest 0, Error 12 Flowchart
(Sheet 3 of 3)

The first test, when it is called by the dispatch routine in the supervisor, sets up a pointer to the I/O status block and tests various drive commands (drive clear, seek, recalibrate, NOP, offset, and reset). Test 1 then performs an oscillating seek test before beginning the data transfer tests.

In the data transfer tests portion of test 1, the program sets up a write transfer of a data pattern (A570A570) to the first block on the disk pack in the drive under test. The data to be written to the disk is loaded into a buffer area in memory. The program then builds an argument list containing the address of the data buffer, the byte count of the data to be transferred, the location of the target block on the disk pack (track, sector, cylinder), the diagnostic buffer address, the event flag number, and the function to be performed. Then, after checking for Control C, the program calls SYS\$QIOW.

If the program is being run in the user mode (VMS environment), the call to SYS\$QIOW invokes a routine in VMS. If the program is being run in the standalone mode, the SYS\$QIOW call invokes a similar routine in the supervisor. SYS\$QIOW builds an I/O packet from the parameters passed from the diagnostic program and then (if in VMS) checks the privilege of the calling process (the diagnostic supervisor) through internal data structures. The SYS\$QIOW routine then places the packet in a queue for processing by a device driven routine, clears the event flag, and waits for completion of the I/O function (indicated by the setting of the event flag). When the driver completes the I/O function, it examines the controller and drive status registers, formulates a status message that is stored in the I/O packet, and loads the diagnostic buffer with drive and adapter register contents. The I/O packet is then inserted into the I/O post queue and a software interrupt to initiate I/O post processing is requested. The I/O post routine performs final I/O request processing and status posting (IOSB), loads the diagnostic buffer with device and adapter (on MBA or UBA) register contents, and sets the event flag.

With the event flag set, the calling program (ESRAA) resumes control. The diagnostic program then checks the I/O Status Block (IOSB) to determine whether or not the requested function was completed successfully. The IOSB has the format shown in Figure 5-16.



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Figure 5-16 I/O Status Block Contents (for disks)

If the low order bit of the first longword of the IOSB is set, indicating success, the program does a branch to the next portion of the test (label 210\$), where it tests the loop flag and then reads the data just written to the disk pack.

If the low order bit of the IOSB is not set, the test calls the CHECKBLOCK routine (refer to the code in Figure 5-17), which is located in the load blocks module (module 6) of the disk reliability program (refer to the link map). This routine, in turn, calls the GETBBFSECTOR routine (Figure 5-18) which reads the load block sector on the disk pack. If the load block file cannot be read at all, the routine returns control to test 1, where the queue I/O request is retried. If the load block file has been read successfully, the routine checks through the item in the file to see if the address of the block which cannot be written to is already noted in the load block file. If so, the load block file is OK, and control returns to test 1, which sets up pointer to access the next block on the disk, builds a new queue I/O argument list, and again calls SYS\$QIOW, as previously explained, in an attempt to write the pattern into the next block on the disk.

If the failing block address is not listed in the load block file, the CHECKBLOCK routine returns control to test 1 which, in turn, issues a second queue I/O request (after checking for Control C). If the request fails again (IOSB status code = 0), the program calls the DS\$ERRHARD routine in the supervisor, which dumps the status block and diagnostic buffer contents and other error information. After detecting a failure of this type, the program checks the loop flag. If the loop flag is set, the program repeats the queue I/O request indefinitely. Otherwise, the program checks each block on the disk pack until it finds one that it can write into successfully, before going on to check the next function (read the block just written, beginning at label 210\$).

```

ZZ=ESRAA=5,2      BAD BLOCK FILE ROUTINES      Fiche 1 Frame L13      Sequence 167
ESRAA6,MAP,BB     MAP RAD BLOCKS ZZ=ESRAA=5,0   VAX=11 MACRO X0,3=6      Page 5
5,0               BAD BLOCK FILE ROUTINES

```

		00000000	144	.PSECT CODES	
		0000	145	CHECK_BLOCK:	
	00FC	0000	146	.WORD	"M<R2,R3,R4,R5,R6,R7,R8,R9,R10,R11>
		0002	147	SDS_GETBUF,S	#1,BBF_POINTER ; ALLOCATE BUFFER
	00	DD		PUSHL	#0
	00	DD		PUSHL	#0
	00000030	EF	7F	PUSHAQ	BBF_POINTER
	01	DD		PUSHL	#1
00000000*9F	04	FR		CALLS	#4, #DSSGETBUF
18	50	E8	0015	BLRS	R0,2\$; SUCCESS?
			148		
			149	SDS_ERRSYS,S	,LUN(AP),MSG_NOMEM
	00	DD		PUSHL	#0
00000000*EF	0F	DF		PUSHAL	MSG_NOMEM
	08	AC	DD	PUSHL	LUN(AP)
	01	DD		PUSHL	#SER
					;; TEST 0, SUBTEST 0, ERROR 1
00000000*9F	04	FB		CALLS	\$\$\$M, #DSSERRSYS
			150	SDS_ABORT	
00000000*9F	6C	FA		CALLG	(AP), #DSSABORT
52	04	AC	9A	MOVZBL	SECTOR(AP),R2 ; PICK UP SECTOR
53	05	AC	9A	MOVZBL	TRACK(AP),R3 ; PICK UP TRACK
54	06	AC	3C	MOVZWL	CYLINDER(AP),R4 ; PICK UP CYLINDER
55	08	AC	00	MOVL	LUN(AP),R5 ; PICK UP LOGICAL UNIT NUMBER
	56	D4		CLRL	R6 ; CLEAR SECTOR COUNTER
57	02	9A		MOVZBL	#2,R7 ; INITIALIZE INDEX OFFSET
58	00000004*EF45	7D		MOVQ	DSKDCQWDLIST+4(R5),R8 ; PICK UP ADDRESS OF DRIVE CHARACTERISTICS
			158		
	55	DD		PUSHL	R5 ; PUSH LUN
	56	DD		PUSHL	R6 ; PUSH SECTOR
000000CA*EF	02	FR		CALLS	#2,GETBRF_SECTOR ; READ BAD BLOCK SECTOR
0A	50	E8		BLRS	R0,SCAN ; BRANCH IF SUCCESS
56	08	91		CMPS	#8,R6 ; HAVE FIRST FIVE SECTORS BEEN READ?
	64	13		BEQL	CHECK_BLOCKZX ; TAKE FAILURE EXIT
	02	C0		ADDL	#2,R6 ; ADD 2 TO SECTOR COUNTER
	E8	11		BRB	10\$; CONTINUE READING
			167	SCAN:	
56	08	9A		MOVZBL	#8,R6 ; INITIALIZE SECTOR COUNTER
	11	11		BRB	20\$; CHECK BLOCK READ FROM PREVIOUS LOOP
	55	DD		PUSHL	R5 ; PUSH LUN
	56	DD		PUSHL	R6 ; PUSH SECTOR NUMBER
000000CA*EF	02	FR		CALLS	#2,GETBRF_SECTOR ; READ NEXT SECTOR
43	50	E9		BLBC	R0,40\$; IF FAILURE TRY NEXT BLOCK
57	02	9A		MOVZBL	#2,R7 ; IGNORE FIRST TWO LONG WORDS OF THE FILE
50	0000003A*FF47	00		MOVL	BBF_POINTER[R7],R0 ; PICK UP BAD BLOCK FILE ITEM
50	FFFF	8F		CMPS	#1,R0 ; CHECK FOR END OF BAD BLOCK FILE
	31	13		BEQL	40\$; IF EOF TRY NEXT SECTOR
54	50	B1		CMPS	R0,R4 ; IF CYLINDERS DON'T MATCH
	24	12		BNEQ	30\$; THEN BRANCH
08	10	E0		CMPS	#16,#8,R0,R2 ; IF SECTORS DON'T MATCH
52	50				
	10	12		BNEQ	30\$; THEN BRANCH
08	18	E0		CMPS	#24,#8,R0,R3 ; IF TRACKS DON'T MATCH
53	50				
	16	12		BNEQ	30\$; THEN BRANCH
			184	SDS_RELBUF,S	#1,BBF_POINTER
	00	DD		PUSHL	#0
00000030*EF	7F	DF		PUSHAQ	BBF_POINTER
	01	DD		PUSHL	#1
00000000*9F	03	FB		CALLS	#3, #DSSRELBUF
50	01	9A		MOVZBL	#1,R0 ; INDICATE SUCCESS
	13	11		BRB	CHECK_BLOCKX ; AND EXIT
57	0000007F	8F		AORLEQ	#127,R7,20\$; IF ALL BLOCKS NOT CHECKED INDEX AND LOOP
	C0				
56	02	C0		ADDL	#2,R6 ; BUMP SECTOR COUNTER BY TWO
0A 48	56	91		CMPS	R6,DSKDCSB_SECTOR(R8) ; CHECK FOR LAST SECTOR
	A6	19		BLSS	10\$; CONTINUE READING IF NOT LAST SECTOR
			191	CHECK_BLOCKZX:	
	50	D4		CLRL	R0 ; ELSE INDICATE FAILURE
			193	CHECK_BLOCKX:	
	04			RET	
			195		; EXIT
			196		
			197		
			198	.SBTTL	GETBRF_SECTOR ROUTINE

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Figure 5-17 CHECKBLOCK
Routine Code

			007C	00CA	268	GETBBF_SECTOR::	
				00CA	269	.WORD	^M<R2,R3,R4,R5,R6>
52	28 AC	00	00CC	270	MOVL	LUN(AP),R2	; PICK UP THE LOGICAL UNIT NUMBER
53	00000004'EF42	7D	00D0	271	MOVQ	DSKDC_QWDLIST+4[R2],R3	; PICK UP POINTER TO DRIVE CHARACTERISTICS
54	00000000'EF	DE	00D8	272	MOVAL	ARGLIST,R4	; R4 <-- POINTER TO LOCAL QIO ARGLIST
	01	83	00DF	273	SUBB3	#1,DSKDC\$B_TRACK(R3),-	
0000'C4	09 A3		00E1	274		QIOSB_TRACK(R4)	; WRITE TRACK TO READ
	01	A3	00E6	275	SUBW3	#1,DSKDC\$W_CYLNDR(R3),-	
0000'C4	0A A3		00E8	276		QIOS\$W_CYLNDR(R4)	; WRITE CYLINDER TO READ
1C A4	00000030'EF	00	00ED	277	MOVL	BBF_POINTER,QIOS_P1(R4)	; WRITE BUFFER ADDRESS INTO QIO ARGLIST
0000'C4	04 AC	90	00F5	278	MOVB	SECTOR(AP),QIOSB_SECTOR(R4)	; WRITE SECTOR TO READ IN QIO ARGLIST
20 A4	0200 8F	3C	00FB	279	MOVZWL	#512,QIOS_P2(R4)	; WRITE BYTE COUNT
04 A4	00000000'EF42	00	0101	280	MOVL	EF_LIST[R2],QIOS_EFN(R4)	; WRITE EVENT FLAG
50	00000000'EF42	00	010A	281	MOVL	QIOPTRLIST[R2],R0	; PICK UP QIO PTR
08 A4	08 A0	00	0112	282	MOVL	QIOS_CHAN(R0),QIOS_CHAN(R4)	; WRITE ASSIGNED CHANNEL
0C A4	0C	00	0117	283	MOVL	#IOS_READPBLK,QIOS_FUNC(R4)	; WRITE READ PHYSICAL FUNCTION CODE
0C A4	00000800 8F	C8	011B	284	BISL	#IOSM_INHERLOG,QIOS_FUNC(R4)	; INHIBIT ERROR LOG
55	00000000'EF42	7E	0123	285	MOVAQ	IOSTATUS_BLOCK[R2],R5	; PICK UP IOSB ADDRESS
10 A4	55	00	012B	286	MOVL	R5,QIOS_IOSB(R4)	; WRITE IOSB ADDRESS INTO QIO ARGLIST
00000000'GF	64	FA	012F	287	\$QIOW_G	(R4)	; ISSUE QIO REQUEST
		04	0136	288	CALLG	(R4),G^SYSSQIOW	
		04	0137	289	RET		; EXIT
			0137	289	.SBTTL	PUT_BADBLK ROUTINE	

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Figure 5-18 GETBBFSECTOR
Routine Code

5.8.2 Disk Reliability Program Sample Error Message

Test 1, Subtest 0, Error 12 of the disk reliability program identifies bad blocks, on the disk pack under test, that are not entered in the bad block file. The message shown in Figure 5-19 identifies the failing test, subtest, and error numbers. The message also includes a dump of the channel registers (MBA registers in this case) and the RM03 registers.

Notice that bits 12 and 15 of the RMER1 register are set, indicating a data check error. The starting cylinder is 0. The bad block is located in sector 1, on track 4, as shown by the contents of the RMDA registers.

TEST 1: QUALIFICATION TEST

DRA1 QA BEGUN AT 2-FEB-1979 14:26:18.54

***** VAX DISK RELIABILITY TESTS ** ESRAA ** -- 5.2 *****

PASS 1 TEST 1 SUBTEST 0 ERROR 12 2-FEB-1977 14:26:20.52

HARD ERROR WHILE TESTING DRA1:

FUNCTION INITIATION SUMMARY:

FUNCTION ATTEMPTED: WRITE DATA

BUFFER ADDRESS RANGE: FROM: 00000388 TO: 00000587

ATTEMPTING BYTE COUNT WAS: 512

STARTING DISK ADDRESS:

CYLINDER: 0 TRACK: 4 SECTOR: 0

FUNCTION ABORT SUMMARY:

UNDEFINED SYSTEM STATUS VALUE = 00000000

MBACSR : 00000020 ; ADAPTER CODE = 20(X)

MBACR : 00000004 ; IE

MBASR : 00002000 ; DT COMP

MBAVAR : 00000388 ; MAP POINTER = 01(X), PAGE BYTE ADDRESS = 188(X)

MBABCR : 00000000 ; MASSBUS BYTE COUNT = 0000 (X), SBI BYTE COUNT = 0000 (X)

MBAFMAP : 800000E7 ; BIT 31, BIT 7, BIT 6, BIT 5, BIT 2, BIT 1, BIT 0

MBAPMAP : 800000F2 ; BIT 31, BIT 7, BIT 6, BIT 5, BIT 4, BIT 1

RMCS1 : 0830 ; DVA, FUNCTION = WRITE DATA

RMDS : 11C0 ; MOL, DPR, DRY, VV

RMER1 : 8000 ; DCK

RMMR : 0028 ; MWR, MSCLK

RMA : 0000 ;

RMDA : 0401 ; TRACK = 04(D), SECTOR = 01(D)

RMDT : 2814 ; MOH, DRQ, DRIVE TYPE = RM03

RMLA : 0040 ; SECTOR = 01(D)

RMSN : 8846 ; SERIAL NUMBER = 8846(X)

RMOF : 1800 ; FMT22, ECCI

RMDC : 0000 ; DESIRED CYLINDER = 0000(D)

RMHR : 0000 ;

RMMR2 : 13FF ; CNT/CYL, BUS IN LINES = 1FF(X)

RMER2 : 0000 ;

RMEC1 : 0836 ; BURST LOCATION = 0836(X)

RMEC2 : 0000 ; ERROR BURST = 0000(X)

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Figure 5-19 ESRAA
Sample Error Listing

CHAPTER 6

CPU CLUSTER EXERCISER PACKAGE

The CPU cluster exerciser package consists of three separate programs (ESKAX, ESKAY, ESKAZ). Two modules, the control module and the common instruction test services module (CITS), are common to all three programs. ESKAX, the first program, is the quick verify portion of the cluster exerciser package. This program includes the compatibility mode entry and exit test, the first part done test, and the SBI exerciser. The second program, ESKAY, contains the timer and clock tests and the native mode instruction set tests. ESKAZ contains the memory management test and the compatibility mode instruction set tests. Figure 6-1 is a map showing the memory allocations of the three programs.

The cluster exerciser diagnostics will handle three classes of errors, providing three corresponding types of error messages: unexpected exceptions or interrupts; test failures; and safe return halts (resulting from fatal errors). The code for the cluster exerciser programs is not as easy to follow as the code for other diagnostic programs. However, the error messages which the programs generate are detailed and, for the most part, self-explanatory. The operator should understand the general structure of each test and the error message formats in order to use all of the facilities provided by the cluster exerciser programs.

6.1 CONTROL MODULE

The control module in the cluster exerciser programs serves as the interface between the programs and the diagnostic supervisor. The module performs the following functions:

- ^ Program initialization and clean up
- ^ Execution of all tests twice in one pass
- ^ Print out of a module summary message at the end of each pass, if errors exist
- ^ Initialization and reinitialization of pertinent control variables
- ^ Set up of all vectors for interrupt and exception handling
- ^ Proper fielding of all exceptions and interrupts (expected and unexpected).

When the control module detects an unexpected interrupt or exception, it prints out an error message as shown in Example 6-1.

ESKAZ (MEMORY MANAGEMENT AND PDP-11 INSTRUCTIONS)	ESKAY (NATIVE INSTRUCTIONS)	ESKAX (QUICK VERIFY)
ESKAX00 10236 CONTROL	ESKAX00 10236 CONTROL	ESKAX00 10236 CONTROL
ESKAX01 18000 CITS	ESKAX01 18000 CITS	ESKAX01 18000 CITS
MEMORY MANAGEMENT 10000 ESKAZ02 TEST 01	TIMER AND CLOCK TESTS 3822 ESKAY02, TEST 01	COMPATIBILITY MODE ENTRY/EXIT 6534 ESKAX02, TEST 1
COMPATIBILITY INSTRUCTIONS 13500 ESKAZ03 TEST 02	ARITHMETIC, LOGIC, AND FIELD INSTRUCTION ESKAY 03, TEST 02	FIRST PART DONE ESKAX04, TEST 2
	BRANCH, CRC, AND QUEUE ESKAY05, TEST 04	SBI VERIFICATION 17155 ESKAX05, TEST 03
	BRANCH, CRC, AND QUEUE ESKAY06, TEST 05	
	OPERAND SPECIFIER FLOATING POINT DEPENDENT ESKAY 07, TEST 06	
	DECIMAL STRINGS ESKAY 08, TEST 07	
	EDITPC OPERATORS ESKAY09, TEST 08	
	CHARACTER STRING INSTRUCTIONS ESKAY10, TEST 09	MEMORY VERIFY ESKAX06, TEST 04
	PRIVILEGED INSTRUCTION EXCEPTION, ESKAY11, TEST 10	

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Figure 6-1 CPU Cluster Exerciser Package Memory Allocation

```

***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 6 SUBTEST 4 ERROR 1 . . . . .
HARD ERROR WHILE TESTING CPU: EXCEPTION SERVICE ROUTINE
UNEXPECTED EXCEPTION
ERROR# 00000001
VECTOR# 00000030
SUBTYPE# 00000006
PSL 83C00000
PC 0000110D

```

Example 6-1 Unexpected Exception Error Message

Refer to Chapter 2 of the VAX-11 KA780 Central Processor Technical Description for a discussion of vectors and subtypes. When the machine check vector is asserted, the exception handler attempts to log out relevant status registers on the stack before pushing two longword parameters (summary and length) on the stack (Table 6-1). In addition, the subtypes for vector 4 (machine check) are listed in Table 6-1.

Table 6-1 Summary Parameter, Length Parameter for Vector 4

Summary Parameter

Subtype	Byte 0
00	CP Read Timeout/SBI Error Confirmation Fault
02	CP TBUF Parity Error Fault
03	CP Cache Parity Error Fault
05	CP Read Data Substitute Fault
0A	Instruction Buffer TBUF Parity Error Fault
0C	Instruction Buffer Read Data Substitute Fault
0A	Instruction Buffer TBUF Parity Error Fault
0C	Instruction Buffer Read Data Substitute Fault
0D	IB Read Timeout/SBI Error Confirmation Fault
0F	IB Cache Parity Error Fault

**Table 6-1 Summary Parameter, Length Parameter for Vector 4
(Cont)**

Summary Parameter	
Subtype	Byte 0
F0	CP Read Timeout/SBI Error Confirmation Abort
F1	CS Parity Error Abort
F2	CP TBUF Parity Error Abort
F3	CP Cache Parity Error Abort
F5	CP Read Data Substitute Abort
F6	CP (Not Supposed To Be Here) Abort
	Byte 1
	This byte will be a nonzero value if a CP timeout or CP error confirmation interrupt is pending.
	Bytes 2 & 3
	These two bytes must be zero.
Length Parameter	
	Byte 0
	The number of bytes logged out are exclusive of this parameter.
	Byte 1--3
	These three bytes must be zero.

When an unexpected interrupt or exception occurs, information is pushed on the stack by the exception handler as shown in Table 6-2.

**Table 6-2 Information Pushed on the Stack
by the Exception Handler**

Mnemonic	Meaning	ID Bus Address
SP:	Length Parameter	
	Summary Parameter	
CES	CPU Error & Status	0C
	Trapped UPC	
	Virtual Address/ Virtual Instruction Buffer Address	
D	Interface Between Data Paths and Memory	08 (Bytes 1 & 3)
TBER0	Translation Buffer Error Register 0	12
TBER1	Translation Buffer Error Register 1	13
TIME.ADDR		1A
PARITY	Cache Parity Register	1E
SBI.ERR	SBI Error Register	19
	PC	
	PSL	

Note that information on the stack is not saved by the exception handler. The EIH module must be breakpointed before this data is accessed.

6.2 COMMON INSTRUCTION TEST SERVICES MODULE (CITS)

This module consists of a group of software routines that implement a table-driven test method for a majority of the VAX-11 instruction set. CITS interprets the contents of a specially coded test table and executes tests of VAX-11 instructions. CITS is also used for tests of the first part done function and memory management. A copy of each of these test instructions is coded in register deferred mode (RN). Before the test instruction is executed, the test data is placed somewhere in memory, and the registers are loaded with the addresses of that test data. After the test instruction is executed, the contents of the registers and the contents of the test data area of memory are checked.

There are four main routines in CITS that do the work of executing tests: CITS_DECODE, CITS_SETUP, CITS_EXECUTE, and CITS_CHECK.

6.2.1 CITS_DECODE

This routine decodes one test table entry, in a table of cases, and generates directions for the other three routines to use. These directions are lists of addresses and other variables placed in the parameter blocks of the CITS data area.

6.2.2 CITS_SETUP

CITS_SETUP moves the test data from the common data pool into the operand buffer. The operand buffer is the location of the data referenced during execution of the test instruction. The locations to be used for destination data are filled with a standard background pattern, hexadecimal A5, in each byte. Also, each operand, whether source or destination, is preceded and followed by a longword of the background pattern. CITS_SETUP loads registers R0--R6 with the operand addresses to be used by the test instruction. The initial PC and PSL calculated by CITS_DECODE are pushed on the stack by CITS_SETUP along with a return address. The return address points to a routine to save the result PSL and registers.

6.2.3 CITS_EXECUTE

CITS_EXECUTE enables the exerciser's exception handler to react properly for the current test. It passes the address of a CITS unexpected exception handler and enables validation of the exception of trace trap being tested, if any. CITS_EXECUTE then executes an REI to start the test. A NOP instruction precedes the REI and can be used for scope sync if the microbreak address is set up correctly from the console. When the test instruction finishes, the test subroutine returns to a result-saving routine. The PSL and registers R0--R6 are saved in the execution parameter block, as are the contents of the exception handler Interface Data Block (IDB). Also saved is an indication of whether the instruction branched, if it is a branch instruction.

6.2.4 CITS_CHECK

CITS_CHECK checks the results of instruction execution, and also checks the source operands and background pattern. It uses the directions and addresses put into its parameter block by

CITS_DECODE to control checking. It checks branches, the PSL, exceptions (whether an exception happened and at the right PC), registers R0--R6, and memory data. When checking memory data, CITS_CHECK also checks the longword before and after each operand to make sure that the background pattern has not been disturbed. CITS_CHECK keeps a list of all errors found during one test case. This complete list will be typed out when the test module using CITS makes the \$DS_ERRHARD call to the diagnostic supervisor.

6.2.5 CITS SUBTEST

CITS_SUBTEST is a common subtest control routine that is used by most of the tests that call CITS. It processes a complete test table, calling the preceding four CITS routines in the proper order and calling the supervisor error reporter when necessary.

6.2.6 CITS Error Messages

6.2.6.1 Message Heading -- A standard diagnostic supervisor heading is typed (by the supervisor). That is followed by an extended error printout that supplies the test, subtest, and error numbers; the test case number; the op code of the failing instruction; addresses referenced; operand data; etc. Refer to Paragraph 6.4.2 for examples and detailed interpretation.

6.2.6.2 CITS Subtest Troubleshooting Features -- SCOPE SYNC -- CITS_EXECUTE executes a NOP instruction just before the REI to the test instruction. Putting the microaddress of 8E into ID Bus register 21 will cause a sync pulse to be generated on the microsequencer board (M8235) each time a NOP is executed.

To loop on a failure with SCOPE SYNC, perform the following steps:

```
>>> D /ID 21 8E
```

```
>>> START 10000
```

(DIAGNOSTIC SUPERVISOR STARTUP)

```
DS> SET IE1,LOOPD
```

```
DS> START /TEST: N (WHERE 'N' IS FAILING TEST NUMBER)
```

ETC.

^ Halt Before the Failing Test Case -- At the beginning of the test-case executing loop, the case number (CITS_CASE) is always incremented and compared with the content of CASE_HALT. If these are equal, a HALT is executed. This feature allows the operator to stop before execution of a particular case, in order to examine registers, e.g., deposit the hex case number into CASE_HALT. Run the test until the halt is executed. (If needed, use CONTINUE until you get to the right subtest.) Then either set a breakpoint or deposit a byte of zero (a

HALT) in CITS_SYNC and type CONTINUE to get to that HALT. You have now stopped just before the REI to the test instruction of interest. Use the console to set up whatever operation you wish to perform and continue as desired.

Figure 6-2 shows the sequence of events followed by CITS in the execution of ESKAY03, test 2, the arithmetic, logic, and field instruction test module.

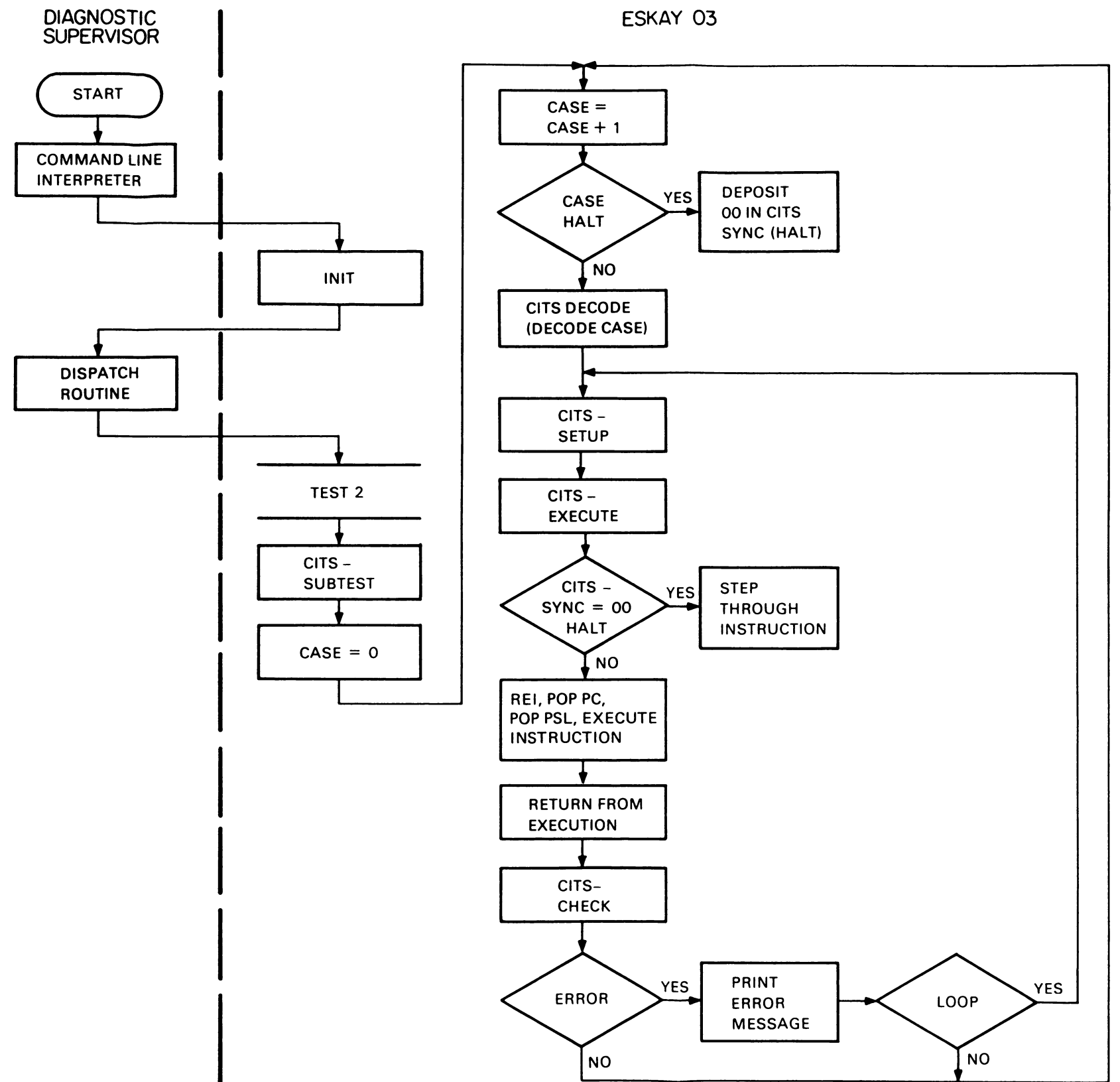
6.2.6.3 Unexpected Exceptions in CITS -- If an unexpected exception occurs during a test, CITS will print a header containing the case number and the error information from the exerciser exception handler. This printout only occurs while CITS is handling unexpected exceptions, i.e., only during the execution of the five instructions before the test instruction and approximately through the three instructions after it (Example 6-2). If an exception occurs outside of that set of instructions, then the error timeout is not handled by CITS and will not have a case number heading.

```
***** CPU CLUSTER EXERCISER -- 9.0 *****  
  
PASS 1 TEST 2 SUBTEST 1 ERROR 25 0  
  
HARD ERROR WHILE TESTING KA0: INSTRUCTION TEST ERROR  
  
? ERROR IN TEST CASE NUMBER: 25  
  
UNEXPECTED EXCEPTION  
  
ERROR# 00000001  
  
VECTOR# 00000004  
  
SUBTYPE# 00000000  
  
PSL 001F00E0  
  
PC 00000003
```

Example 6-2 Unexpected Exception in CITS, Error Message

Refer to Example 6-1 (Paragraph 6.1) for an explanation of the unexpected exception error message format.

6.2.6.4 Result Register Errors -- If the contents of any of the registers R0--R6 are not as expected, CITS prints out initial, expected, and actual values, as shown in Example 6-3.



TK-0755

Figure 6-2 Execution of a Test Case in ESKAY03

```

***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 2 SUBTEST 4 ERROR 17 0
HARD ERROR WHILE TESTING KA0: INSTRUCTION TEST ERROR
? ERROR IN TEST CASE NUMBER: 17
? REGISTER CONTENTS ERROR

```

	INITIAL	EXPECTED	ACTUAL
R0	00005404	00003800	00003880
R1	00005414	00008000	00008000
R2	00005418	00000000	00000000
R3	00000000	00005476	00005476
R4	00000000	00000000	00000000
R5	00000000	00000000	00000000
R6	00000000	00000000	00000000

Example 6-3 Result Register Errors

Initial data shows the values loaded into the registers at the start of the instruction.

6.2.6.5 Leading or Trailing Background Errors -- If the longword before or the longword after an operand is changed during execution, CITS reports the error. Leading means the longword before the data (lower address than the data). Hexadecimal A5A5A5A5 is the standard background pattern.

6.2.6.6 Data Errors -- When CITS detects a data error, part of the error typeout is an operand number. That is, a number in the range 1 to 6 corresponding to the left-to-right order of the operands for the instruction. For example, in a MOVL instruction the source longword will be called operand 1 and the destination longword operand 2.

If the incorrect operand is not of a writable or modifiable access type, then the error message includes the statement: read-only operand overwritten.

If the incorrect operand is writable or modifiable, then the error message includes the statement: incorrect result (Example 6-4).

```

***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 2 SUBTEST 7 ERROR 10 0
HARD ERROR WHILE TESTING KA0: INSTRUCTION TEST ERROR

? ERROR IN TEST CASE NUMBER: 10
? INCORRECT RESULT OPERAND 2

EXPECTED          ACTUAL
C00000000         400000000

```

Example 6-4 CITS Detects a Longword Data Error

Example 6-4 shows incorrect longword data. For word and byte data errors, the format is the same except that a word is typed as four hex digits, and a byte as two hex digits. In a quadword or double-floating word typeout, the lowest addressed longword is the first line of data typed. That is the longword containing the sign and the exponent for the double-floating case. (In the quadword case, the sign is in the longword typed on the second line of data, Example 6-5.)

```

***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 2 SUBTEST 1 ERROR 91 0
HARD ERROR WHILE TESTING KA0: INSTRUCTION TEST ERROR

? ERROR IN TEST CASE NUMBER: 91
? INCORRECT RESULT, OPERAND 2

EXPECTED          ACTUAL
000000000         996740D6
000000000         86A2E99E

```

Example 6-5 CITS Detects a Quadword Data Error

Errors in string data (character string, packed decimal string, etc.) are displayed in Example 6-6.

```

***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 2 SUBTEST 1 ERROR 44 0
HARD ERROR WHILE TESTING KA0: INSTRUCTION TEST ERROR

? ERROR IN TEST CASE NUMBER: 44
? INCORRECT RESULT, OPERAND 4

EXPECTED          ACTUAL
38                ...A5A5*39*4E39...
0 BYTES FROM START OF STRING

```

Example 6-6 CITS Detects a String Data Error

Each byte is typed as two hexadecimal digits. The expected data only shows the good value of the byte that did not compare. The actual data shows five bytes of the result string. The beginning of the string is to the left, the end is to the right. The left hand two bytes (four digits) are good result data; the byte between asterisks (*) is the one that failed to compare; and the right two bytes are the start of the rest of the (uncompared) string. The last line tells how far from the beginning of the string the bad byte is.

6.2.6.7 PSL Errors -- Result PSL errors are typically wrong condition codes. The condition codes are the right-hand hex digit of the PSL. The E in the second from right-hand digit indicates that the decimal overflow, floating underflow, and integer overflow traps are enabled (Example 6-7). This condition is always true when the test instruction is being executed.

```

***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 2 SUBTEST 1 ERROR 50 0
HARD ERROR WHILE TESTING KA0: INSTRUCTION TEST ERROR

? ERROR IN TEST CASE NUMBER: 50
? RESULT PSL ERROR

EXPECTED          ACTUAL
001F00E8          001F00E1

```

Example 6-7 PSL Error

6.2.6.8 Branch Errors -- When testing instructions that may branch, failure to branch when expected or a branch taken when not expected produces a message like that in Example 6-8.

```
*****      CPU CLUSTER EXERCISER -- 9.0      *****  
PASS 1  TEST 2  SUBTEST 4  ERROR 1  0  
HARD ERROR WHILE TESTING KA0: INSTRUCTION TEST ERROR  
  
? ERROR IN TEST CASE NUMBER: 1  
? EXPECTED BRANCH DIDN'T HAPPEN
```

Example 6-8 Branch Error

6.2.6.9 Expected Exception or Trace Trap Errors

1. An error message is produced if an expected exception or trace trap fails to occur at all.
2. The PC and PSL of expected exceptions and trace traps are checked. If an error is detected, a message like that in Example 6-9 is typed.

```
*****      CPU CLUSTER EXERCISER -- 9.0      *****  
PASS 1  TEST 2  SUBTEST 4  ERROR 2  0  
HARD ERROR WHILE TESTING KA0: INSTRUCTION TEST ERROR  
  
? ERROR IN TEST CASE NUMBER: 2  
? INCORRECT EXCEPTION PC  


|          |          |
|----------|----------|
| EXPECTED | ACTUAL   |
| 000025F5 | 00002566 |

  
? INCORRECT EXCEPTION PSL  


|          |          |
|----------|----------|
| EXPECTED | ACTUAL   |
| 001F00E5 | 001F00E4 |


```

Example 6-9 Expected Exception Error

In Example 6-9 both the PC and the PSL were incorrect at the time of the exception. In Example 6-10 only the PSL was wrong at the time a valid trace trap occurred.

```

***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 2 SUBTEST 2 ERROR 127 0
HARD ERROR WHILE TESTING KA0: INSTRUCTION TEST ERROR

? ERROR IN TEST CASE NUMBER: 127
? INCORRECT TRACE TRAP PSL

EXPECTED          ACTUAL
001F00F0          001F00F8

```

Example 6-10 Trace Trap Error

6.2.6.10 Extended Printout -- If the extended error printout flag is enabled, the following additional data will be typed out on error detection (Example 6-11).

```

[1.] INITIAL CONDITIONS:

PC 00004873 PSL 001F00FF

OP CODE -- 74 WITH REGISTER INDIRECT OPERANDS

[2.] INITIAL REGISTERS R0-R6:

R0      0000AC04 R1      0000AC14 R2      000
R3      0000AC2D R4      0000AC39 R5      000
R6      00000000

[3.] SOURCE OPERAND DATA:

OPERAND 1

FFFE4FFF

FFFFFFFF

OPERAND 2

FF

OPERAND 3

00004080

00000000

```

Example 6-11 Extended Printout

Notes for Example 6-11.

1. This is the first line of the extended typeout. PC is the location of the test instruction, which can be examined if the user wants to see the hex code.

PSL is the value of the PSL before the instruction is executed.

OP CODE is the hex value of the instruction, which in the example is 74 = EMODD.

REGISTER INDIRECT OPERANDS means that R0 has the address of operand 1; R1 has the address of operand 2; etc.

2. The INITIAL REGISTERS typeout tells where the operands of the test instruction were in memory when the instruction was executed.
3. These are the actual contents of the addresses pointed to by the registers listed above (2).

All source (read or modifiable) operands are typed.

Formats:

Byte	XX
Word	XXXX
Longword	XXXXXXXX
Quadword	XXXXXXXX -- Low Address Longword XXXXXXXX -- High Address Longword
Strings	XX, XX, XX, XX,...,XX Left side of printout is lowest address byte. Long strings are printed 16 bytes per line and are continued for as many lines as needed.

In the preceding example we have the following operands. (Refer to the VAX-11/780 Architecture Handbook or the instruction card for further help.)

Operand 1	MULR	(R0)	Double	FFFFFFFF FFFE4FFF
Operand 2	MULRX	(R1)	Byte	FF
Operand 3	MULD	(R2)	Double	00000000 00004080

The 4th and 5th Operands are Destinations:

Operand 4	INT	(R3)	Long
Operand 5	FRACT	(R4)	Double

6.2.7 How To NO-OP a Test Case

If it is necessary to bypass a test case while waiting for a hardware ECO or a microcode ECO, refer to Example 6-12.

	2C9	946	;CASE 105		
	2C9	947	;SUBD2 INSTRUCTION		
	2C9	948	;		
	2C9	949	;		
	2C9	950	;OPERANDS		
	2C9	951	;SUB: 0		
	2C9	952	;DIF: 1.0		
	2C9	953	;CONDITION CODES		
	2C9	954			
	2C9	955	TB I_SUBD2, CC_NZVC, CC_0, D8_D12, D8_D2, DP_D2		
08F09D62	2C9		.BYTE I_SUBD2, <-C<I_SUBD2>>, <I6*<CC_NZVC&15>+CC_0&15>>		
08	2CC		.BYTE DP_D12		
01	2CD		.BYTE DP_D2		
01	2CE		.BYTE DP_D2		

Example 6-12 Case 105 SUBD2
Instruction

Load ESKAX.EXE

Look up the base address of the PSECT <. BLANK .> in the link map of this program for the module that has the data for the test case to be No-Oped.

Set the console base register to that value (i.e., SE R: VALUE).

Find the TB line of the right test case and examine it to make sure you are in the right place (Example 6-12).

Examination of 2C9 location (E 2C9) should give 08F09D62.

Count the number of single bytes following the line that has three bytes. That would be 3 for this example.

Deposit a new longword, at the address just examined, made up of the count from the preceding step followed by 03FC.

In Example 6-12, D 2C9 303FC, where 2C9 is the address just examined.

Set the relocation register back to zero when finished (i.e., SE R: 0).

6.3 ESKAX DESCRIPTION

6.3.1 Compatibility Mode Entry/Exit Module (ESKAX02, Test 01)

This module tests the conditions generated when the central processor enters and leaves the compatibility mode. The following conditions and functions are tested.

ESKAX Test 1, Subtest 1 -- This subtest performs illegal entries in compatibility mode expecting and checking for reserved operand faults. The bit settings in the PSL that will cause reserved operand faults, on an attempt to enter compatibility mode, are shown in Table 6-3.

Table 6-3 Reserved Operand Faults and PSL Bit Settings on Compatibility Mode Entry

PSL Bit/s	Condition
DV<7>	Nonzero
FU<6>	Nonzero
IV<5>	Nonzero
IPL<20:16>	Nonzero
CUR MOD<25:24>	Not = 3
PRV MOD<23:22>	Not = 3
IS<26>	Nonzero
FPD<27>	Nonzero

The conditions in Table 6-3 are tested one at a time.

The following two examples are typical of ESKAX test 1, subtest 1, error messages.

```
***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 1 SUBTEST 1 ERROR 2 19-JUN-1977 21:25:41.22
HARD ERROR WHILE TESTING CPU: EXCEPTION PC FROM CM ILLEGAL ENTRY
                                INCORRECT
VECTOR  TYPE CODE  EXPECTED PC  ACTUAL PC  PSL ENTRY  MNEMONIC
18      NONE      00007D74    00007D76    83C00080    DV
```

Example 6-13 ESKAX Test 1, Subtest 1, Error 2

```
***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 1 SUBTEST 1 ERROR 2 19-JUN-1977 21:25:53.04
HARD ERROR WHILE TESTING CPU: EXCEPTION PC FROM CM ILLEGAL ENTRY
                                INCORRECT
VECTOR  TYPE CODE  EXPECTED PC  ACTUAL PC  PSL ENTRY  MNEMONIC
18      NON       00007D74    00007D54    83C00040    FU
```

Example 6-14 ESKAX Test 1, Subtest 1, Error 2

Interpretation of Example 6-13.

1. 18 is the reserved operand fault vector expected.
2. There is no type code pushed on the stack.
3. The state of the PSL to cause the fault was 83C00080.
4. DV is the PSL bit that was nonzero (Table 6-3).
5. EXPECTED and ACTUAL PCs are self-explanatory.

ESKAX Test 1, Subtest 2 -- Compatibility mode trap instructions upon a valid entry into compatibility mode (Table 6-4).

Table 6-4 Compatibility Mode Trap Instructions

Op code	Mnemonic
000003	BPI
000004	IOT
104000	EMT+0
104400	TRAP+0

-- Compatibility mode reserved instructions upon a valid entry into compatibility mode (Table 6-5).

Table 6-5 Compatibility Mode Reserved Instructions

<u>Op code</u>	<u>Mnemonic</u>
000000	HALT
000001	WAIT
000005	RESET
000230	SPL
006400	MARK
075000	FADD
075010	FSUB
075020	FMUL
075030	FDIV
170000	FP11

Typical Error Messages

```

***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 1 SUBTEST 2 ERROR 3 19-JUN-1977 21:29:30.40
HARD ERROR WHILE TESTING CPU: EXCEPTION PSL FROM COMPATIBILITY
MODE TRAP INCORRECT
VECTOR TYPE CODE EXPECTED PSL ACTUAL PSL TRAP MNEMONIC
30 1 83C00000 83C00002 0003 BPT

```

Example 6-15 ESKAX Test 1, Subtest 2, Error 3

```

***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 1 SUBTEST 2 ERROR 3 19-JUN-1977 21:29:42.21
HARD ERROR WHILE TESTING CPU: EXCEPTION PSL FROM COMPATIBILITY
MODE TRAP INCORRECT
VECTOR    TYPE CODE    EXPECTED PSL    ACTUAL PSL    TRAP    MNEMONIC
30        2            83C00000      83C00002      0004    IOT

```

Example 6-16 ESKAX Test 1, Subtest 2, Error 3

```

***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 1 SUBTEST 2 ERROR 3 19-JUN-1977 21:29:54.02
HARD ERROR WHILE TESTING CPU: EXCEPTION PSL FROM COMPATIBILITY
MODE TRAP INCORRECT
VECTOR    TYPE CODE    EXPECTED PSL    ACTUAL SPL    TRAP    MNEMONIC
30        3            83C00000      83C00002      8800    EMT

```

Example 6-17 ESKAX Test 1, Subtest 2, Error 3

Interpretation of Example 6-16

1. 30 is the compatibility mode TRAP vector expected.
2. A type code of 2 is pushed on the stack.
3. Referencing Chapter 6 of the system reference manual would show that a typecode of 2 indicates an IOT fault.
4. IOT is shown as well as the hex equivalent of the octal code (Table 6-4).
5. EXPECTED and ACTUAL PSLs are self-explanatory.

Subtest 3 -- This subtest tests the T-bit trap by having the T-bit (PSL<4>) set upon entry into compatibility mode:

- a. for an instruction that does not trap
- b. for an instruction that does trap.

NOTE

Both a and b cases are serviced in
NATIVE mode.

Typical Error Message

```
***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 1 SUBTEST 3 ERROR 4 19-JUN-1977 21:32:06.80
HARD ERROR WHILE TESTING CPU: A T-BIT TRAP NOT TAKEN
EXPECTED EXC VECTOR TYPE CODE MNEMONIC
0BC0 30 NONE TST R0
```

Example 6-18 ESKAX Test 1, Subtest 3, Error 4

Interpretation of Example 6-18 (this printout is for Case B):

1. This instruction, which was to execute and then take a T-bit trap, was 'TST R0' with TRACE PENDING prior to its execution (PSL<TP>).
2. The hex equivalent of the octal code for 'TST R0' is BC0.
3. 30 is the vector expected to field the T-bit trap.
4. No type code is pushed on the stack.

Subtest 4 -- This subtest performs an RTT/RTI instruction with the T-bit set in the PSW image on the stack, which is to be popped from the stack by the RTT/RTI.

Typical Error Messages

```
***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 1 SUBTEST 4 ERROR 3 19-JUN-1977 21:33:43.60
HARD ERROR WHILE TESTING CPU: PC FROM RTT TRACE TRAP
INCORRECT
VECTOR TYPE CODE EXPECTED PC ACTUAL PC TRAP MNEMONIC
30 NONE 00008508 00008408 0006 RTT
```

Example 6-19 ESKAX Test 1, Subtest 4, Error 3

```

***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 1 SUBTEST 4 ERROR 3 19-JUN-1977 21:33:54.70
HARD ERROR WHILE TESTING CPU: PC FROM RTI TRACE TRAP
INCORRECT
VECTOR    TYPE CODE    EXPECTED PC    ACTUAL PC    TRAP        MNEMONIC
30        NONE        00008508      00008408      0002        RTI

```

Example 6-20 ESKAX Test 1, Subtest 4, Error 3

Interpretation of Example 6-19

1. 30 is the vector expected to field the T-bit trap.
2. No type code is pushed on the stack.
3. The RTT instruction was under test.
4. The hex equivalent of the octal code for RTT is 6.
5. EXPECTED and ACTUAL PCs are self-explanatory.

Subtest 5 -- This subtest performs checking of Odd Address errors while in compatibility mode. This is accomplished by executing a PDP-11 MOV instruction with unaligned SRC and DST operands.

Typical Error Messages

```

***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 1 SUBTEST 5 ERROR 4 19-JUN-1977 21:35:17.19
HARD ERROR WHILE TESTING CPU: ODD ADDRESS TRAP CAUSED
UNALIGNED SOURCE CONTENTS CHANGE
VECTOR    TYPE CODE    EXPECTED VAL    ACTUAL VAL    TRAP        MNEMONIC
30        6          000A          000E          17DF        UNALIGNED

```

Example 6-21 ESKAX Test 1, Subtest 5, Error 4

```

***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 1 SUBTEST 5 ERROR 4 19-JUN-1977 21:35:29.58
HARD ERROR WHILE TESTING CPU: ODD ADDRESS TRAP CAUSED
UNALIGNED SOURCE CONTENTS CHANGE
VECTOR    TYPE CODE    EXPECTED VAL    ACTUAL VAL    TRAP        MNEMONIC
30        6          000A          000E          17DF        UNALIGNED
DST

```

Example 6-22 ESKAX Test 1, Subtest 5, Error 4

Interpretation of Example 6-22

1. 30 is the compatibility mode TRAP vector expected.
2. A type code of 6 is pushed on the stack.
3. The position of the destination address on a boundary caused the failure.
4. The hex equivalent of the octal code for the instruction under test is 17DF (this translates to 013737 in PDP-11 code).
5. EXPECTED and ACTUAL VALUES are self-explanatory.

NOTE

On an Odd Address trap neither SRC nor DST initial values should change, since the instruction should not go to completion.

Subtest 6 -- This subtest performs checking of illegal instructions with a register destination, i.e.,

JMP R4 or
JSR R4, R5

Typical Error Messages

```
***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 1 SUBTEST 6 ERROR 3 19-JUN-1977 21:36:32.03
HARD ERROR WHILE TESTING CPU: PSL FROM ILLEGAL INSTRUCTION
TRAP INCORRECT
VECTOR    TYPE CODE    EXPECTED PSL    ACTUAL PSL    TRAP        MNEMONIC
30         5            83C00000       83D00000       0044        JMP R4
```

Example 6-23 ESKAX Test 1, Subtest 6, Error 3

```
***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 1 SUBTEST 6 ERROR 3 19-JUN-1977 21:36:43.64
HARD ERROR WHILE TESTING CPU: PSL FROM ILLEGAL INSTRUCTION
TRAP INCORRECT
VECTOR    TYPE CODE    EXPECTED PSL    ACTUAL PSL    TRAP        MNEMONIC
30         5            83C00000       83000000       0905        JSR (R5 DST)
```

Example 6-24 ESKAX Test 1, Subtest 6, Error 3

Interpretation of Example 6-24

1. 30 is the vector expected to field the TRAP.
2. A type code of 5 is pushed on the stack.
3. The instruction that failed was the JSR R4, R5.
4. The hex equivalent for the octal code of this instruction is 0905.
5. EXPECTED and ACTUAL PSLs are self-explanatory.

ESKAX02 (test 1) is executed in the user mode for test purposes. However, the module is serviced in the kernel mode, and control is returned to the kernel mode on completion of the module.

The operator should note that testing of the T-bit operation with servicing done in the compatibility mode has not been covered.

6.3.2 First Part Done Test (ESKAX04, Test 2)

First Part Done (FPD) is the name of bit 27 in the PSL. It provides a facility for interrupting certain potentially long executing instructions during processing and resuming them later. Only a few instructions are interruptable in this sense. Most instructions acknowledge interrupts before their execution, or acknowledge them in mid-operation by backing up to the beginning and pretending that they have not yet started. A few instructions, however, are potentially so lengthy that this is not feasible. These are the character and decimal string instructions, POLYF, POLYD, and CRC. Each of these instructions writes a control block into the general registers. Should an interrupt be requested during processing, the current state of the operation (i.e., what it is doing and how far it has gotten) can be saved in this control block to be retrieved after the interrupt is processed. The instruction then sets FPD in the PSL, and acknowledges the interrupt. Upon return from the interrupt, the FPD bit is set in the PSL, so that rather than restarting, the instruction restores its state from the point at which it was interrupted.

6.3.2.1 Possible First Part Done Failures -- The microcode implementing the FPD capability must be able to correctly save and restore state anywhere it does a memory reference (which may cause a fault) and anywhere it checks for interrupts. The state of the operation in some cases is complex, and it is possible that the microcode does not save or restore everything correctly. If the instruction is later resumed, the state of the machine e.g., in the form of contents of general registers, may well have been changed by the instructions executed in the interim, and will thus be incorrect. This will cause unpredictable results, most likely in the form of incorrect data written, wrong lengths and wrong condition codes, and will be easy to detect.

The instructions may also fail by saving state (perhaps correctly) and failing to set FPD. This would normally appear when modified registers are used as arguments in the restarting of the instruction. This condition will be detected in the test by checking in the interrupt routine to make certain that if FPD is still clear, the original arguments are unchanged.

6.3.2.2 First Part Done Test Procedures -- The interval timer is used to generate interrupts during the testing of each instruction, in order to check the microcode and the taking of interrupts. Although each instruction is interrupted constantly during execution, it is eventually run to completion.

After having been tested with interrupts, the instruction's ability to handle page faults is tested. An instruction may have up to six operands; twelve pages are set up to hold them, allowing each operand to be placed near an independent page boundary. When the instruction begins execution, each page is invalid. As it attempts to access its operands, the instruction is repeatedly

faulted. Each fault validates the page referenced, so that the instruction progresses, but this alone does not ensure that it is tested fully. As each page is referenced (and faulted) the first time, all the other pages holding operands are made invalid. This process tests all the cases. Since each page has a first reference only once, the test instruction manages to finish.

As an example, consider the testing of an instruction with two string operands and one non-string operand in which the instruction accesses the non-string operand first, and then processes the strings (e.g., CMP3). First, the non-string operand is referenced, faulting the page containing it. Upon restart, the instruction fetches the non-string operand without problem, and begins processing the strings. Since each operand is located just before a page boundary, the strings will cross the boundaries. As the instruction progresses, it will attempt to reference the first page of the first operand, the first page of the second operand, the second page of the first operand, and the second page of the second operand. Because faulting in a page for the first time signals the test to invalidate all the other pages, however, the string of references and validations proceeds as shown in Table 6-6.

Table 6-6 Page Faulting with First Part Done

Page 1	Page 2	Page 3	Page 4	
I	I	I	I	;All the pages start invalid.
FAULT	I	I	I	;The first page is faulted
V	I	I	I	;and is made valid.
V	I	FAULT	I	;The first page of operand 2 is
I	I	V	I	;faulted in, and the rest out.
FAULT	I	V	I	;Page 1 is refaulted, and page
V	I	V	I	;3 is left valid.
V	FAULT	V	I	;String 1 processing reaches
I	V	I	I	;page 2, all others faulted.
I	V	FAULT	I	;Page 1 is not needed now, but
I	V	V	I	;page 3 still is needed.
I	V	V	FAULT	;String 2 reaches its second
				;page
I	I	I	V	;faulting page 4 for first
				;time.
I	FAULT	I	V	;Page 2 is still needed, and
I	V	I	V	;is faulted back in.
I	V	I	V	;The instruction is completed.

The first part done test uses the CITS routines to help set up, execute, and check the results of instruction tests. The instructions to test, and the data with which to test them, are stored in a table. The table entries are of variable length, and they begin as shown in Table 6-7.

Table 6-7 First Part Done Test Table Entries

.BYTE	0	;the op code of the test instruction
.BYTE	0	;the op code's complement
.BYTE	0	;initial condition codes
.BYTE	0	;resultant condition codes
.BYTE	0	;operand specifiers
	.	
	.	
	.	

The faulting section uses the Interface Data Block (IDB) to communicate with the exception and interrupt handler. The format of the IDB is shown in Table 6-8.

Table 6-8 First Part Done IDB Format

T-Bit Count	Exception and Subtype	State Bits
PSL of exception		
PC of exception		
PSL of latest T-bit trap		
PC of latest T-bit trap		
User service routine address		
Number of arguments (zero)		

The service routine address points to the code that implements the faulting algorithm. The exception type and subtype are loaded with the values for translation-not-valid faults.

This test also interfaces with the CITS routine through a Test Control Block (TCB). The TCB format is shown in Table 6-9.

Table 6-9 First Part Done TCB General Format

Current Test Table Address			
Unused	Exception	Subtype	T-bit trap
Operand 1 address, or 0			
Operand 2 address, or 0			
Operand 3 address, or 0			
Operand 4 address, or 0			
Operand 5 address, or 0			
Operand 6 address, or 0			

The current test table address points into the table of test instructions.

The TCB passed to CITS_DECODE and to CITS_REDECODE is shown in Table 6-10.

Table 6-10 First Part Done TCB Passed to CITS_DECODE

TCB:

TCB_INST_ADDR:	.LONG	0	;current test table address
TCB_T_BIT:	.BYTE	0	;trace trap expected flag
TCB_SUBTYPE:	.BYTE	0	;exception subtype
TCB_EXCEPTION:	.BYTE	0	;expected exception vector
	.BYTE	0	;unused
TCB_OPERANDS:	.BLKL	6	;optional operand addresses

Typical Error Message

```

***** CPU CLUSTER EXERCISER -- 9.0 *****

PASS 1 TEST 2 SUBTEST 0 ERROR 212 19-JUN-1977 21:41:22.03

HARD ERROR WHILE TESTING CPU: An unexpected type of fault
occurred.

Fault code      Referenced address      PC          PSL
00000000      0001F7F8          00003DD0    000000EB

Table number    Test case
1               1

TCB's address   Test table address      Current entry address
00008F9C       00000A7C          00000A7C

```

Example 6-25 ESKAX Test 2, Subtest 0, Error 212

Interpretation of Example 6-25

The printout is representative of the first part done test, which interfaces to the CITS portion of the program for its data pool as follows.

1. This test interfaces with CITS through the TCB whose format is shown in Table 6-10.

In this example, the first address of the TCB is 8F9C.

The current test table address (which is the first longword of the TCB) is given as A7C.

2. The starting address of the test table within CITS is A7C.

3. CITS contains a number of tables; each table contains a number of cases (or distinct pieces of data) where:

Table 1 represents BASE FP instructions

Table 2 represents DECIMAL instructions

Table 3 represents EDIT PC instructions

Table 4 represents FPA instructions

A summary of the information presented so far on the First Part Done Test follows.

- a. We are using Table 1 from CITS for our data.
- b. The starting address of this table is A7C.
- c. We are using DATA CASE 1.
- d. The address for DATA CASE 1 is A7C.
- e. The address of the CONTROL BLOCK guiding this test execution is 8F9C (whose format is shown above in Table 6-10).
- f. Examination of the next n locations starting with the CURRENT ENTRY ADDRESS (in this case A7C) will give information concerning the instruction under test as follows:

1st byte is the op code of the test instruction.

2nd byte is the op code's complement.

3rd byte is the INITIAL condition code (N,Z,V,C).

4th byte is the RESULTANT condition code (N,Z,V,C).

The next n bytes represent operand specifiers.

The number of operand specifiers depends on the instruction under test.

4. The starting address of the area where the test instruction is placed (residing) while undergoing test is the PC of 3DD0.

A Second Error Message

```
***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 2 SUBTEST 0 ERROR 213 19-JUN-1977 21:41:22.03
HARD ERROR WHILE TESTING CPU: Page fault on non-test instruction.
Fault Code      Reference address  PC          PSL
00000000      0001FFF8          00003DD0    000000EB
Table number    Test case
1              1
TCB's address   Test table address  Current entry address
00008F9C       00000A7C          00000A7C
```

Example 6-26 ESKAX Test 2, Subtest 0, Error 213

Interpretation of Example 6-26

The REFERENCE ADDRESS of 1FFF8 represents the address which caused the FAULT CODE of 0.

The breakdown of the FAULT CODE is as follows:

Bit Position	Meaning
0	0 = translation not valid 1 = access control violation
1	1 = fault occurred during virtual reference to the PTE of the stored process virtual address
2	0 = read access 1 = write or modify access

The interrupts portion of the test begins by setting up the test instruction and data, using the CITS routines named CITS_DECODE and CITS_SETUP.

CITS_SETUP returns with the PC and initial PSL of the test instruction on the stack. The test saves a copy of the test instruction's PC and general registers, so that its progress may be observed. Then the test initializes the interval timer service routine.

It then sets up a timer interrupt and executes an REI to the test instruction, which is interrupted immediately.

Since the state of the instruction is contained in the registers, if they are unchanged since the previous interrupt, the instruction has not progressed. This condition results from interrupting too soon. In this case, the interval timer is increased, and the test instruction is resumed.

In the other case, when the general registers have changed, the instruction has progressed.

Next, a divide-packed instruction is executed in an attempt to modify the state of any internal registers that might be used by the instruction under test. The timer is then set up for the new wait time, started, and the test instruction is resumed.

When the test instruction has been completed, the results are checked and any errors are reported.

Once interrupts and faults have been tried, the next entry in the test instruction table is selected, and the testing of that instruction begins.

There are four classes of errors that may occur.

Class 1 -- Unexpected exceptions or interrupts.

Class 2 -- Exception or interrupt identifier reports, which simply state

ERROR IN TEST CASE NN.

These occur when an exception or interrupt occurs during the testing of an instruction, and they are immediately followed by the exception report. They exist solely to inform the operator of the test case in which the exception occurred.

Class 3 -- Instruction test errors describe incorrect results from instruction testing. The instructions tested are a subset of those tested in ESKAY05_TEST04 and ESKAY06_TEST05, so that the instruction test errors are identical between those tests and this test, ESKAX04_TEST02. This data is in module ESKAX03_FPD_DATA.

Class 4 -- These errors are first part done specific (Example 6-27).

They have error numbers 200 through 209. Each reports error specific information, the table number, and the test case number. The interpretation of table numbers is as follows:

Table Number	Meaning
1	Floating-point test table
2	Decimal string test table
3	EDITPC test table
4	Floating-point test table (Executed with FPA enabled if an FPA exists)

The test case number indexes into the appropriate table to indicate a single test.

```

***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 2 SUBTEST 0 ERROR 207 . . . . .
HARD ERROR WHILE TESTING CPU:  EXPECTED TIMER INTERRUPTS DIDN'T
                                OCCUR.

VALUE PASSES
-30

TABLE NUMBER    TEST CASE
1                115

TCB'S ADDRESS   TEST TABLE ADDRESS   CURRENT ENTRY ADDRESS
18E0            9F6                    9F6

```

Example 6-27 ESKAX Test 2, Subtest 0, Error 207

6.3.3 SBI Verification Module (ESKAX05, Test 3)

The SBI verification test is designed to exercise and partially diagnose faults on the SBI nexus connected to it. Error reports will differentiate between faults on the SBI proper and faults caused by a nexus. The error printouts will serve as guides to selection of the appropriate repair level diagnostic to further isolate the problem.

With the exception of the interactive mode setup subtest, errors will be reproducible via looping. For interactive mode, due to the asynchronous operation of the exerciser, only errors introduced by interrupts from the interval timer are guaranteed to be reproducible.

Note that failing devices are deselected from further testing at the point of failure. This means that if an MBA or UBA fails in a test before MBE or UBE checkout, the MBEs or UBEs attached are not checked for the failing MBA or UBA.

The SBI verification test is composed of the following parts.

- ^ SBI checkout -- Verifies configuration register of each nexus that can be accessed.
- ^ UBA checkout -- Verifies that each selected UBA on the SBI can sustain data transfers without incurring errors and that interrupts occur at the proper BR level.
- ^ MBA checkout -- Verifies that each selected MBA on the SBI can sustain data transfers without incurring errors and that interrupts occur at the proper BR level.
- ^ SBI interaction -- Verifies that all UBAs are capable of block data transfers in a controlled sequential mode of operation.
- ^ UBE checkout -- Verifies that all existing UBEs are capable of sustaining data transfers and interrupting on completion without errors.
- ^ MBE checkout -- Verifies that all existing MBEs for selected MBAs are capable of sustaining data transfers and interrupting on completion without errors.

6.3.3.1 SBI Checkout Subtest -- The SBI checkout subtest will perform reads and writes to the configuration register of each nexus on the SBI as defined by the hardware P-Table. This subtest will set up the Hardware Interrupt Request Table (HIRT), which will contain an entry for each UBA and/or MBA responding to a read of its configuration/status register. This table will be used by all subtests within the SBI verification test. A nexus that does not respond will not be entered into the HIRT and, therefore, will not be used in the following subtests. No response from a nexus is treated as an error.

The SBI checkout subtest uses the CPU silo comparator register to check the validity of the commands and responses from the receiving nexus on the SBI.

The primary purpose of this subtest is to provide the field user with a detailed check of the SBI. It will isolate faults in such a manner that the error information printed will aid the user in the selection of the proper diagnostic, which may then be run to further isolate the fault.

^ Silo Compare Servicing -- The silo compare service routine will read back the SBI silo and compare the contents with the arguments supplied in the IDB (interface data block). Null cycles between command issue and read reply are checked for continuity of function, i.e., TR lines not continually asserted. No checking will be made for the number of null cycles.

On completion of the silo read back, the fault bit in the CPU SBI status register will be checked for clear. The error flag will be set and the appropriate information will be placed on the error stack if it is set. The fault bit will be reset if set. The interrupt on silo compare bit will be cleared and the SBI silo compare register will be cleared.

A return is then made to the point of invocation of the interrupt causing this routine to be executed.

6.3.3.2 UBA Checkout Subtest -- This subtest will only be run for UBAs that exist in the HIRT and have been qualified by the SBI checkout subtest.

Each UBA will be set up to operate in a wraparound mode so that access from the SBI to Unibus memory space will be mapped into SBI memory space.

This subtest will check the following UBA capabilities.

1. DDP and BDPl data paths are operational.
2. Interrupts can be initiated by the adapter and result in the correct vector being accessed.
3. The map registers can be accessed and used correctly.
4. Purging operates correctly.
5. A read to nonexistent Unibus memory space causes the correct error sequence and interrupt.

The subtest will autosize the Unibus memory and set the map register disable portion of the Unibus Adapter Control Register (UACR) for use by other subtests within the SBI verification test.

Faults detected within this subtest will cause the UBA under test to be disqualified from further use by any other subtest within the SBI verification test.

UBA Interrupt Servicing -- Interrupts generated by the Unibus Adapter are serviced by this routine.

The routine will compare the configuration register and the Unibus Adapter Status Register (UASR) with arguments supplied in the Service Data Block (SDB). If there are any differences, they will be pushed on the error stack and the error flag will be set. For an invalid map register type interrupt, the failed mapped entry register will be compared with the SDB entry. Also, for a Unibus SSYN timeout, the failed Unibus address register will be compared with the SDB entry.

The AEIL (Additional Exception or Interrupt Longword) is used as the transfer vehicle to indicate to the interrupted program the IPL level at which the interrupt occurred.

6.3.3.3 MBA Checkout Subtest - This subtest is run only on MBAs that exist in the HIRT and have been qualified by the SBI checkout subtest.

Each MBA is set up to operate in maintenance mode.

This subtest checks the following MBA capabilities.

1. Initialization clears registers and does not cause interrupts.
2. DT_BUSY can be set and causes no interrupts.
3. PGE can be set and causes an interrupt.
4. Read and write transfers operate correctly; on completion of read data transfer, DONE is set and causes an interrupt.

Faults detected within this subtest cause the MBA under test to be disqualified from further use by any other subtest within the SBI verification test.

MBA Interrupt Servicing -- Interrupts generated by the Massbus adapter are serviced by this routine.

This routine compares the status register with an argument supplied in the SDB.

If there are any differences, the SDB + 2 will be set to indicate error and the error information will be put into the appropriate slots in the Master Control Space (MCS).

6.3.3.4 SBI Interaction Subtest -- After the UBAs are set up for wraparound operation, the following data transfer types are initiated.

1. read word
2. write byte
3. write word
4. modify byte
5. modify word

6.3.3.5 UBE Checkout Subtest -- This subtest determines the number and location of Unibus exercisers for each Unibus adapter and checks each as it is found. If no faults are detected, the UBE is entered in the HIRT and the qualify bit will be set.

Only qualified UBAs are used during this subtest. If none exists, the subtest will be skipped.

UBAs are set up with two map registers pointing to SBI memory space. One map uses the Direct Data Path (DP0) and the other uses buffered Data Path One (DP1). All interrupts are enabled.

Autosizing is used to determine the location of a Unibus exerciser.

Each exerciser is checked for the following two capabilities:

1. ability to execute DATO, DATI functions,
2. ability to interrupt at BR levels 4 through 7 following a function.

If any of the above conditions is not met, the UBE is not entered in the HIRT.

UBE Interrupt Servicing -- The contents of the BRRVR and UBA base address are passed into the test from the master exception and interrupt handler. In addition, the routine performs the following four functions.

1. If bit 31 is set in the BRRVR value read, then call the UBA service routine.
2. Derive the UBE address from the vector supplied in the low word of the BRRVR value.
3. Examine bit 15 (error bit) of CR1. If the bit is set, push the error type information and contents of the control registers, CR1 and CR2, on the error stack and set the error flag. Clear the error bit.
4. Return.

6.3.3.6 MBE Checkout Subtest -- This subtest determines if an MBE is present for each MBA that has been previously qualified.

Each exerciser will be checked for the following:

1. read transfers
2. write transfers.

Additionally, the MBA is checked for whether

1. Attention can be set which causes an interrupt.
2. Massbus exception can be set which causes an interrupt.

If any of the above conditions is not met, the MBE is not entered in the HIRT.

Typical Error Messages for the SBI Verification Module:

```
***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 3 SUBTEST 2 ERROR 10 19-JUN-1977 21:53:25.06
HARD ERROR WHILE TESTING UBA: INVALIDATED MAP REGISTER ACCESS
ERROR: DESTINATION OVERWRITTEN
ADD ACCESS    NEXUS ADD    MR ADD    FUNC    EXP DATA    ACT DATA
201009F8      60006000      60006810  WRITE    25255252      24255252
```

Example 6-28 ESKAX Test 3, Subtest 2, Error 10

```
***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 3 SUBTEST 3 ERROR 4 19-JUN-1977 21:57:03.12
HARD ERROR WHILE TESTING MBA0: MBA WRITE
ERROR: RESULT
ADD ACCESS    NEXUS ADD    EXP DATA    ACT DATA
60010400      60010000      00002000      00002400
```

Example 6-29 ESKAX Test 3, Subtest 3, Error 4

```
***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 3 SUBTEST 3 ERROR 4 19-JUN-1977 21:57:13.07
HARD ERROR WHILE TESTING MBA1: MBA WRITE
ERROR: RESULT
ADD ACCESS    NEXUS ADD    EXP DATA    ACT DATA
60012400      60012000      00002000      00003000
```

Example 6-30 ESKAX Test 3, Subtest 3, Error 4

Interpretation of Example 6-28

These printouts are typical of ESKAX Test 2, where:

1. The nexus address is 60006000. A nexus is defined as a physical connection to the SBI. In this case the nexus is the UBA.
2. Since the SBI deals in 30-bit addresses, 18-bit Unibus addresses must be translated to 30-bit SBI addresses. This function is performed by the Unibus adapter through one of the 496 UBA memory map registers, as shown in Table 6-11.

Table 6-11 Unibus Adapter Map Register Address Offsets

Unibus Memory Page	Offset from the UBA Base Address
0	800
1	804
2	808
3	80C
4	810
.	.
.	.
.	.
495	FBC
.	FC0
.	.
.	.
.	Reserved
.	FFC

In the example given, the MR ADDRESS is 60006810. The underlined portion of the address (using Table 6-11) tells us that we are working with the map register for Unibus memory, page 4.

One Unibus memory page equals 512 bytes.

3. The function performed was a write.
4. Each UBA has an associated Unibus address space with a physical starting address as follows:

UBA Number	Physical Starting Address
0	20100000
1	20140000
2	20180000
3	201C0000

From Example 6-28 the ADDRESS ACCESSED is 201009F8, indicating UBA 0 under test.

5. EXPECTED and ACTUAL DATA are self-explanatory.

6.3.3.7 Memory Verify (ESKAX06_TEST04) -- Not yet implemented.

6.4 ESKAY

6.4.1 Interval Timer and Day Clock Verification Module (ESKAY02 TEST01)

This module tests the interval timer and the day clock. The interval timer is used extensively throughout the cluster exerciser package during interactive operation.

6.4.1.1 Interval Timer Functions

Subtest 1 -- The interrupt enable bit in the control status register can be set and cleared.

Typical Error Message

```
***** CPU CLUSTER EXERCISER -- 9.0 *****  
PASS 1 TEST 1 SUBTEST 1 ERROR 2 18-JUN-1977 06:38:05.10  
HARD ERROR WHILE TESTING CPU: INTERRUPT ENABLE BIT CAN'T BE  
CLEARED
```

Example 6-31 ESKAY Test 1, Subtest 1, Error 2

Subtest 2 -- This subtest checks that the transfer bit (bit 04) in the control status register can be set, thus activating a transfer of the contents of the next interval register to the current interval register.

A check that the transfer bit is read as 0 is also performed.

Typical Error Messages

```
***** CPU CLUSTER EXERCISER -- 9.0 *****  
PASS 1 TEST 1 SUBTEST 2 ERROR 1 18-JUN-1977 6:39:58.61  
HARD ERROR WHILE TESTING CPU: XFER BIT STUCK AT 1
```

Example 6-32 ESKAY Test 1, Subtest 2, Error 1

```
***** CPU CLUSTER EXERCISER -- 9.0 *****  
PASS 1 TEST 1 SUBTEST 2 ERROR 2 18-JUN-1977 06:39:58.61  
HARD ERROR WHILE TESTING CPU: XFER FROM NEXT INTERVAL TO INTERVAL  
COUNT INCORRECT
```

Example 6-33 ESKAY Test 1, Subtest 2, Error 2

Subtest 3 -- The single clock bit (bit 5) in the control status register can be set, thus causing the current interval register to advance by one.

The test also checks that the single clock bit is read as zero.

```
***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 1 SUBTEST 3 ERROR 2 18-JUN-1977 06:43:14.82
HARD ERROR WHILE TESTING CPU: SINGLE CLOCK BIT NOT FUNCTIONING
PROPERLY
```

Example 6-34 ESKAY Test 1, Subtest 3, Error 2

Subtest 4 -- This test floats a one through a field of zeros in the current interval register. The medium of transfer is the read/write unit comprised of the current interval register and the next interval register, respectively. Since the next interval register is write-only, only the current interval register is checked at the end of the transfer. If a failure is detected in the current interval register, it is possible that the failure originated in the next interval register.

Typical Error Message

```
***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 1 SUBTEST 4 ERROR 1 18-JUN-1977 06:44:31.89
HARD ERROR WHILE TESTING CPU: ADJACENT PIN STICKING IN INTERVAL
COUNT REGISTER

EXPECTED RESULT RECEIVED RESULT ENTRY VALUE
00000004        00000006        00000004
```

Example 6-35 ESKAY Test 1, Subtest 4, Error 1

Interpretation

1. The ENTRY VALUE of 00000004 represents the value loaded into the next interval register (hex 19).
2. The EXPECTED RESULT of 00000004 represents what the content of the current interval register (hex 1A) should be after the transfer is complete.
3. The RECEIVED RESULT is self-explanatory.

Subtest 5 -- This subtest checks the carry bits of the current interval register. This is accomplished by preloading the next interval register with the value to force the carry, transferring this to the next interval register, and then single-clocking to force the carry expected.

Typical Error Message

```
***** CPU CLUSTER EXERCISER -- 9.0 *****  
  
PASS 1 TEST 1 SUBTEST 5 ERROR 1 18-JUN-1977 06:45:50.65  
  
HARD ERROR WHILE TESTING CPU: INTERVAL TIMER COUNTING NOT  
PROCEEDING PROPERLY  
  
EXPECTED RESULT RECEIVED RESULT ENTRY VALUE  
00000002 00000001 00000001
```

Example 6-36 ESKAY Test 1, Subtest 5, Error 1

```
***** CPU CLUSTER EXERCISER -- 9.0 *****  
  
PASS 1 TEST 1 SUBTEST 5 ERROR 1 18-JUN-1977 06:45:50.65  
  
HARD ERROR WHILE TESTING CPU: INTERVAL TIMER COUNTING NOT  
PROCEEDING PROPERLY  
  
EXPECTED RESULT RECEIVED RESULT ENTRY VALUE  
00000004 00000003 00000003
```

Example 6-37 ESKAY Test 1, Subtest 5, Error 1

Interpretation of Example 6-36

1. The ENTRY VALUE of 00000001 represents the value loaded into the next interval register (hex 19).
2. The EXPECTED RESULT of 00000002 represents what the content of the current interval register (hex 1A) should be after the transfer is complete and the single clock bit has been ticked once.
3. The RECEIVED RESULT is self-explanatory.

Subtest 6 -- This subtest checks that the error bit in the control status register will set in the case of a current interval register overflow occurrence before a previous interrupt has been serviced.

The error messages are self-explanatory.

```
***** CPU CLUSTER EXERCISER -- 9.0 *****  
PASS 1 TEST 1 SUBTEST 6 ERROR 1 18-JUN-1977 06:53:13.11  
HARD ERROR WHILE TESTING CPU: INTERRUPT REQUEST NOT SET ON  
OVERFLOW
```

Example 6-38 ESKAY Test 1, Subtest 6, Error 1

```
***** CPU CLUSTER EXERCISER -- 9.0 *****  
PASS 1 TEST 1 SUBTEST 6 ERROR 2 18-JUN-1977 06:53:13.11  
HARD ERROR WHILE TESTING CPU: ERR NOT SET FROM UNSERVICED OVERFLOW
```

Example 6-39 ESKAY Test 1, Subtest 6, Error 2

Subtest 7 -- This subtest checks the run bit of the control status register with the interrupt enable bit not set (i.e., a check of no interrupt capability).

Typical Error Message

```
***** CPU CLUSTER EXERCISER -- 9.0 *****  
PASS 1 TEST 1 SUBTEST 7 ERROR 3 18-JUN-1977 06:53:13.11  
HARD ERROR WHILE TESTING CPU: ERR BIT SET -- SHOULD NOT BE
```

Example 6-40 ESKAY Test 1, Subtest 7, Error 3

Subtest 8 -- This subtest checks the run bit of the control status register with the interrupt enable bit set, a check of interrupt capability. A check is also made to verify that the interrupt is enabled at IPL 24 (hex 18).

Typical Error Message

```
***** CPU CLUSTER EXERCISER -- 9.0 *****  
PASS 1 TEST 1 SUBTEST 8 ERROR 2 18-JUN-1977 06:55:56.48  
HARD ERROR WHILE TESTING CPU: INTERRUPT OCCURRED AT OTHER THAN IPL  
24  
  
IPL WAS 18
```

Example 6-41 ESKAY Test 1, Subtest 8, Error 2

Interpretation of Example 6-41

1. The IPL WAS would indicate at what IPL level the interrupt did occur (if other than IPL 24).

6.4.1.2 Day Clock Function

Subtest 9 -- This subtest checks the ability of the time of day register to advance from a known state, given 20 ms to do so.

Typical Error Message

```
***** CPU CLUSTER EXERCISER -- 9.0 *****  
PASS 1 TEST 1 SUBTEST 9 ERROR 1 18-JUN-1977 06:58:26.79  
HARD ERROR WHILE TESTING CPU: TIME OF DAY CLOCK NOT INCREMENTING
```

Example 6-42 ESKAY Test 1, Subtest 9, Error 1

Subtest 10 -- This subtest checks the ability of the time of day register to accept a back-to-back loading of two different and unique values.

Typical Error Message

```
***** CPU CLUSTER EXERCISER -- 9.0 *****  
PASS 1 TEST 1 SUBTEST 10 ERROR 2 18-JUN-1977 06:59:43.78  
HARD ERROR WHILE TESTING CPU: DOUBLE LOADING OF TIME OF DAY NOT  
CORRECT  
  
EXPECTED RESULT RECEIVED RESULT 1ST LOAD 2ND LOAD  
AAAAAAAC AAAAAAAA 55555555 AAAAAAAA
```

Example 6-43 ESKAY Test 1, Subtest 10, Error 2

Subtest 11 -- This subtest checks for any stuck-at-zero bits in the time of day register.

Typical Error Message

```
***** CPU CLUSTER EXERCISER -- 9.0 *****  
PASS 1 TEST 1 SUBTEST 11 ERROR 1 18-JUN-1977 07:00:30.34  
HARD ERROR WHILE TESTING CPU: ADJACENT PIN STICKING IN TIME OF DAY  
REGISTER  
  
EXPECTED RESULT RECEIVED RESULT ENTRY VALUE  
FFFFFFFFE FFFFFFFF FFFFFFFD
```

Example 6-44 ESKAY Test 1, Subtest 11, Error 1

Subtest 12 -- This subtest checks the Carry bits of the time of day register. This is accomplished by preloading the time of day register with the value to force the Carry, and then expecting a Carry bit in approximately 14--15 ms.

```
***** CPU CLUSTER EXERCISER -- 9.0 *****  
PASS 1 TEST 1 SUBTEST 12 ERROR 2 18-JUN-1977 07:05:02.22  
HARD ERROR WHILE TESTING CPU: TIME OF DAY COUNTING NOT PROCEEDING  
PROPERLY  
  
EXPECTED RESULT RECEIVED RESULT ENTRY VALUE  
00000002 00000001 00000001
```

Example 6-45 ESKAY Test 1, Subtest 12, Error 2

Interpretation of Example 6-45

1. The ENTRY VALUE of 00000001 is what is initially loaded into the time of day register.
2. The EXPECTED RESULT of 00000002 is the final value expected to be in the time of day register approximately 14 ms after the initial load.
3. The RECEIVED RESULT is self-explanatory.

In addition, the test checks for stuck-at-zero bits in the time of day register.

6.4.2 Arithmetic, Logic, and Field Instruction Test Module (ESKAY03, Test 02)

This module tests the integer arithmetic, logical, and field instruction microcode and associated hardware. CITS performs all of the functional control, building expected data patterns, executing the instructions to be tested, and checking the results.

The following two printouts are typical of error reports coming from this test.

- a. One shows a result PSL error.
- b. The second shows incorrect operand result contents.

```
***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 2 SUBTEST 1 ERROR 1 6-AUG-1978 11:34:41.92
HARD ERROR WHILE TESTING CPU: INSTRUCTION TEST ERROR
? ERROR IN TEST CASE NUMBER: 1
? RESULT PSL ERROR

    EXPECTED    ACTUAL
    000000E5    000000E1

INITIAL CONDITIONS:
PC 00004958 PSL 000000EF
OP CODE -- 90 WITH REGISTER INDIRECT OPERANDS

INITIAL REGISTERS R0--R6:
R0 0000AE04 R1 0000AE0D R2 00000000
R3 00000000 R4 00000000 R5 00000000
R6 00000000

SOURCE OPERAND DATA:

OPERAND 1
05
```

Example 6-46 ESKAY Test 2, Subtest 2, Error 1

```

*****      CPU CLUSTER EXERCISER -- 9.0      *****
PASS 1  TEST 2  SUBTEST 1  ERROR 31  6-AUG-1978  11:35:27.25
HARD ERROR WHILE TESTING CPU: INSTRUCTION TEST ERROR

? ERROR IN TEST CASE NUMBER: 31
? INCORRECT RESULT, OPERAND 2

      EXPECTED      ACTUAL
      00004300      00004304
      00000000      00000000

INITIAL CONDITIONS:
PC 000046FA PSL 000000EF
OP CODE -- 6C WITH REGISTER INDIRECT OPERANDS
INITIAL CONDITIONS:
R0  0000AE04   R1  0000AE0D   R2  00000000
R3  00000000   R4  00000000   R5  00000000
R6  00000000

SOURCE OPERAND DATA:
OPERAND 1
21

```

Example 6-47 ESKAY Test 2, Subtest 1, Error 31

Interpretation of Example 6-47

1. The op code 6C defines the instruction under test as CVTBD (you can know this by simply looking up the given op code on a coding card).
2. The general format of this instruction (again from looking at the code card) is as follows:

op code scr.rx, dst.wy

The statement WITH REGISTER INDIRECT OPERANDS indicates that the form of the instruction being tested is CVTBD (R0), (R1).

NOTE

All instruction testing is set up so that the first operand always uses R0, second operand always uses R1, third operand always uses R2, etc.

3. The initial conditions PC and PSL should be self-explanatory.
4. The TEST CASE NUMBER of 31 shows nothing more than how far into the current test table we are, i.e., 30 instruction types were tested up to this point with no errors.

For all intents and purposes, you can ignore this number.

5. The error indication of INCORRECT RESULT, OPERAND 2 states that the final contents of the destination operand were wrong. OPERAND 2 is shown above as (R1).
6. The SOURCE OPERAND DATA of 21 is self-explanatory.
7. The INITIAL REGISTERS R0--R6 specify the addresses in memory in use for the instruction. In this case, CVTBC (AE04), (AE0D).

NOTE

R2 through R6 contain 0s since the CVTBD instruction uses only two operands.

8. Finally, the EXPECTED value of 4300 and the ACTUAL value of 4304.

If you examine the content of AE0D (/W) it should contain 4304.

Example 6-48 is another form of printout similar to the preceding two examples with a twist. An unexpected exception occurred during the testing of an instruction.

```

***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 2 SUBTEST 3 ERROR 1 6-AUG-1978 11:34:42.57
HARD ERROR WHILE TESTING CPU: INSTRUCTION TEST ERROR

? ERROR IN TEST CASE NUMBER: 1

    UNEXPECTED EXCEPTION

ERROR# 00000001
VECTOR# 00000034
SUBTYPE# 00000001
PSL 000000EB
PC 00004933

INITIAL CONDITIONS:
PC 00004930 PSL 000000E0
OP CODE -- 8E WITH REGISTER INDIRECT OPERANDS

INITIAL REGISTERS R0--R6:
R0 0000AE04 R1 0000AE0D R2 00000000
R3 00000000 R4 00000000 R5 00000000
R6 00000000

SOURCE OPERAND DATA:
OPERAND 1
80

```

Example 6-48 ESKAY Test 2, Subtest 3, Error 1

Interpretation of Example 6-48

1. The unexpected exception occurred through VECTOR 34 (Paragraph 2.7 of the KA780 Central Processor Technical Description lists VECTOR 34 as the ARITHMETIC TRAP vector).
2. The SUBTYPE of 1 informs you that the condition was INTEGER OVERFLOW (Paragraph 2.7 of the KA780 Central Processor Technical Description).
3. The PC of 4933 and PSL of EB are those existing at the time of the exception occurrence.
4. The ERROR 1 is nothing more than a repetition of the ERROR 1 printout of the header report.
5. The rest of the printout is as outlined for the two printouts preceding (i.e., the same breakdown applies).

6.4.3 Branch, CRC, and Queue Test Module (ESKAY04, Test 03)
Not yet implemented.

6.4.4 Floating-Point Instructions Test Module (ESKAY05, Test 4; ESKAY06, Test 5)

Tests 4 and 5 check both the basic floating-point instructions and the accelerated floating-point instructions. Arithmetic and reserved operand exceptions pertaining to floating-point instructions are also tested. Since the FPA takes part in the execution of MULL2 and MULL3, the tests also check these instructions. The floating-point accelerator is turned off for test 4 and on for test 5.

Typical Error Messages for Test 4

```
***** CPU CLUSTER EXERCISER (ZZ-ESKAY) -- 9.0 *****
PASS 1 TEST 4 SUBTEST 1 ERROR 2 20-FEB-1978 11:26:00.00
HARD ERROR WHILE TESTING CPU: INSTRUCTION TEST ERROR

? ERROR IN TEST CASE NUMBER: 2
? RESULT PSL ERROR

    EXPECTED    ACTUAL
    001F00E3    001F00E1

INITIAL CONDITIONS:
PC 00004420 PSL 001F00EF
OP CODE -- 4F WITH REGISTER INDIRECT OPERANDS

INITIAL REGISTERS R0--R6:
R0 0000AC04 R1 0000AC10 R2 0000AC1C
R3 00000000 R4 00000000 R5 00000000
R6 00000000

SOURCE OPERAND DATA:

OPERAND 1
00004080

OPERAND 2
00004080

OPERAND 3
00000000
```

Example 6-49 ESKAY Test 4, Subtest 1, Error 2

***** CPU CLUSTER EXERCISER (ZZ-ESKAY) -- 9.0 *****

PASS 1 TEST 4 SUBTEST 1 ERROR 7 20-FEB-1978 11:26:00.00

HARD ERROR WHILE TESTING CPU: INSTRUCTION TEST ERROR

? ERROR IN TEST CASE NUMBER: 7

? RESULT PSL ERROR

EXPECTED	ACTUAL
----------	--------

001F00E5	001F00E4
----------	----------

INITIAL CONDITIONS:

PC 00004695 PSL 001F00EB

OP CODE -- 71 WITH REGISTER INDIRECT OPERANDS

INITIAL REGISTERS R0--R6:

R0	0000AC04	R1	0000AC14	R2	00000000
----	----------	----	----------	----	----------

R3	00000000	R4	00000000	R5	00000000
----	----------	----	----------	----	----------

R6	00000000
----	----------

SOURCE OPERAND DATA:

OPERAND 1

00004080

00000000

OPERAND 2

00004080

00000000

Example 6-50 ESKAY Test 4, Subtest 1, Error 7

***** CPU CLUSTER EXERCISER (ZZ-ESKAY) -- 9.0 *****

PASS 1 TEST 4 SUBTEST 1 ERROR 24 20-FEB-1978 11:26:00.00

HARD ERROR WHILE TESTING CPU: INSTRUCTION TEST ERROR

? ERROR IN TEST CASE NUMBER: 24

? RESULT PSL ERROR

EXPECTED	ACTUAL
----------	--------

001F00E8	001F00E0
----------	----------

INITIAL CONDITIONS:

PC 00004873 PSL 001F00EF

OP CODE -- WITH REGISTER INDIRECT OPERANDS

INITIAL REGISTERS R0--R6

R0	0000AC04	R1	0000AC14	R2	0000AC1D
----	----------	----	----------	----	----------

R3	0000AC2D	R4	0000AC39	R5	00000000
----	----------	----	----------	----	----------

R6	00000000
----	----------

SOURCE OPERAND DATA:

OPERAND 1

FFFE4FFF

FFFFFFFF

OPERAND 2

FF

OPERAND 3

00004080

00000000

Example 6-51 ESKAY Test 4, Subtest 1, Error 24

A lengthy detailed description of this type of error report has been supplied in Paragraph 6.4.2. Using that description as a reference, interpretations of the preceding three error reports follow.

Interpretation of Example 6-49

The instruction being tested is

ACBF (R0), (R1), (R2), displacement

BREAKING DOWN FURTHER--

ACBF (AC04), (AC10), (AC1C), displacement

BREAKING DOWN FURTHER--

ACBF 4080, 4080, 0, displacement

↓ ↓ ↓
limit addend index

Interpretation of Example 6-50

The instruction being tested is

CMPD (R0), (R1)

BREAKING DOWN FURTHER--

CMPD (AC04), (AC14)

BREAKING DOWN FURTHER--

CMPD 4080, 4080

↓ ↓
source destination

Interpretation of Example 6-51

Going through a similar analysis

EMODD (R0), (R1), (R2), integer, fraction

EMODD FFFE4FFF 00004080

FFFFFFFF, FF, 00000000, integer, fraction

↓ ↓
floating-point multiplier multiplicand

↓
floating-point multiplier extension

Typical Error Messages for Test 5

```
***** CPU CLUSTER EXERCISER (ZZ-ESKAY) -- 9.0 *****
PASS 1 TEST 5 SUBTEST 2 ERROR 7 20-FEB-1978 11:26:00.00
HARD ERROR WHILE TESTING CPU: INSTRUCTION TEST ERROR

? ERROR IN TEST CASE NUMBER: 7
? INCORRECT TRACE TRAP PSL

    EXPECTED    ACTUAL
    001F00F5    001F00F4

INITIAL CONDITIONS:
PC 00004695 PSL 001F00FB
OP CODE -- 71 WITH REGISTER INDIRECT OPERANDS
INITIAL REGISTERS R0--R6:
R0 0000AC04 R1 0000AC14 R2 00000000
R3 00000000 R4 00000000 R5 00000000
R6 00000000

SOURCE OPERAND DATA:
OPERAND 1
00004080
00000000
OPERAND 2
00004080
00000000
```

Example 4-52 ESKAY Test 5, Subtest 2, Error 7

```

***** CPU CLUSTER EXERCISER (ZZ-ESKAY) -- 9.0 *****
PASS 1 TEST 5 SUBTEST 8 ERROR 100 20-FEB-1978 11:26:00.00
HARD ERROR WHILE TESTING CPU: FLOATING NORMALIZE SUBTEST

? ERROR IN TEST CASE NUMBER: 113

    EXPECTED    ACTUAL
    FFF849FF    00003F80

TEST AT PC: 00009A87  ADDF3 R0, R2, R4

    R0  00004080

    R2  0000C040

```

Example 6-53 ESKAY Test 5, Subtest 8, Error 100

```

***** CPU CLUSTER EXERCISER (ZZ-ESKAY) -- 9.0 *****
PASS 1 TEST 5 SUBTEST 8 ERROR 101 20-FEB-1978 11:26:00.00
HARD ERROR WHILE TESTING CPU: FLOATING NORMALIZE SUBTEST

? ERROR IN TEST CASE NUMBER: 161

    EXPECTED    ACTUAL
    00004040    00004000
    00000000    00000000

TEST AT PC: 00009B11  ADD3 R0, R2, R4

    R1  0000C000
    R2  FFFF4D7F
    R3  0000E000

```

Example 6-54 ESKAY Test 5, Subtest 8, Error 101

The interpretation of Example 6-52 is similar to that already given for Example 6-47.

Examples 6-53 and 6-54 are for the FLOATING NORMALIZE SUBTEST and differ from the standard CITS printouts as follows:

1. Both printouts give the instructions under test and their operands, i.e.,

```
ADDF3 R0, R2, R4
ADD3 R0, R2, R4
```

2. The operand data is listed directly under the TEST AT PC statements.
3. The EXPECTED and ACTUAL data in both cases reference the contents of R4 (R4, by definition, specifies the destination operand).

6.4.5 Operand Specifier Dependent Floating-Point Test (ESKAY07, Test 6)
Not yet implemented.

6.4.6 Decimal Strings Module (ESKAX08, Test 7)
This module tests the microcode and hardware used for decimal string execution.

Interpretation of Example 6-55

The error printouts coming from this test are designed like those of test 5. An overall interpretation has already been described in the test 2 writeup.

Analysis should show the instruction under test to be

```
ADDP6 (R0), (R1), (R2), (R3), (R4), (R5)
      ↓      ↓      ↓      ↓      ↓
      addladdr add2addr sumaddr
      ↓      ↓      ↓
      addllen add2len sumlen
```

with ADDRESSES REFERENCED shown under INITIAL REGISTERS R0--R6 and OPERAND DATA as indicated.

6.4.7 EDITPC Operators Module (ESKAY09, Test 8)
This module tests the EDITPC microcode and associated hardware.

Typical Error Message

```
***** CPU CLUSTER EXERCISER (ZZ-ESKAY) -- 9.0 *****
PASS 1 TEST 7 SUBTEST 2 ERROR 26 20-FEB-1978 11:26:00.00
HARD ERROR WHILE TESTING CPU: INSTRUCTION TEST ERROR

? ERROR IN TEST CASE NUMBER: 26
? INCORRECT TRACE TRAP PSL

    EXPECTED    ACTUAL
    001F00F8    001F00F0

INITIAL CONDITIONS:
PC 00004585 PSL 001F00FF
OP CODE -- 21 WITH REGISTER INDIRECT OPERANDS

INITIAL REGISTERS R0--R6
R0 0000AC04 R1 0000AC0E R2 0000AC1B
R3 0000AC25 R4 0000AC35 R5 0000AC3F
R6 00000000

SOURCE OPERAND DATA:
OPERAND 1
0009
OPERAND 2
12, 34, 56, 78, 9C
OPERAND 3
000E
OPERAND 4
00, 00, 00, 77, 77, 77, 77, 7E
OPERAND 5
001F
```

Typical Error Message

```
***** CPU CLUSTER EXERCISER (ZZ-ESKAY) -- 9.0 *****
PASS 1 TEST 8 SUBTEST 1 ERROR 48 20-FEB-1978 11:26:00.00
HARD ERROR WHILE TESTING CPU: INSTRUCTION TEST ERROR

? ERROR IN TEST CASE NUMBER: 48
? RESULT PSL ERROR

    EXPECTED    ACTUAL
    001F00E5    001F00E4

INITIAL CONDITIONS:
PC 0000485A PSL 001F00EB
OP CODE -- 38 WITH REGISTER INDIRECT OPERANDS

INITIAL REGISTERS R0--R6:
R0 0000AC04 R1 0000AC0E R2 0000AC1E
R3 0000AC2F R4 00000000 R5 00000000
R6 00000000

SOURCE OPERAND DATA:
OPERAND 1
0000F

OPERAND 2
00, 00, 00, 00, 00, 00, 00, 0D

OPERAND 3
40, 40, 43, 25, 04, 9F, 46, 10, 00
```

Example 6-56 ESKAY Test 8, Subtest 1, Error 48

Interpretation of Example 6-56

The error printouts coming from this test are designed like those described in Paragraph 6.4.2.

Therefore, analysis should show the instruction under test to be

```
EDITPC      (R0),   (R1),   (R2),   (R3)
             ↓       ↓       ↓       ↓
             srclen  srcaddr  pattern dstaddr
```

with ADDRESSES REFERENCED shown under INITIAL REGISTERS R0--R6 and OPERAND DATA as indicated.

6.4.8 Character String Instructions Test Module (ESKAY10, Test 9)

Not yet implemented.

6.4.9 Privileged Instruction Exception Test (ESKAY11, Test 10)

Not yet implemented.

6.5 ESKAZ DESCRIPTION

6.5.1 Memory Management Test Module (ESKAZ03, Test 1)

The object of this test is to test memory management on a VAX-11/780 CPU. Memory management is that part of the CPU which checks protection on memory references, performs virtual to physical address translation, monitors updates to pages of memory (with the modify bit of the page table entry), and resolves unaligned data references. These functions are tested by making many different kinds of references to see that they work. Working is defined as: reading or writing the correct data, leaving the contents of adjacent addresses unaffected, setting the M bit on the first write to a page, and faulting if required. Upon detecting a failure, the test issues an error report containing the failure symptom (e.g., unexpected fault, wrong condition codes) and the circumstances surrounding the failure (instruction and address under test, expected and received data, etc.).

The test is organized in six subsections, each testing some area of memory management functionality.

1. Valid read and write -- The intent is to quickly verify that the basic functions work. Longword aligned reads and writes are performed to each address space (P0, P1, and System). This process performs initial checks of reading and writing, physical address translation in each address space, translation buffer loading, and setting of the modify bit.

2. Length register boundary checks - References are made just before and just beyond each of the length boundaries to verify the length boundary checks.
3. Page Table Entry (PTE) combinations -- This subsection changes privilege modes to kernel, exec, super, and user. It makes references to pages mapped with each access code, and with the PTEs both valid and invalid, to verify the access privilege checks.
4. Size with PTE combinations -- The size of the access is varied from byte to quadword and tried with PTE combinations.
5. Page boundary checks -- The size of the access and the position of the access with respect to a page boundary are varied.
6. IB references with PTE combinations -- This subsection attempts to make instruction buffer references while varying the protection of the referenced page.

6.5.1.1 Memory Management Test General Flow

Initialization -- Three buffer areas are requested from the supervisor, one each from P0, P1, and system spaces. A control block (BVAS) is loaded with their addresses, and with the addresses of three other buffer areas, which are on the last page in each space.

Execution of Subsections -- A loop selects and executes each of the subsections, as follows.

1. **Select an SCC** -- The entry in the subsection description table associated with the current subsection is selected. It includes a pointer to a Setup Command Chain (SCC). There is an SCC for each subsection. The execution section includes six nested loops, varying access size, address space, and operand alignment. The SCC contains start and end limits for these loops. For instance, the SCC for the fourth loop, page boundary checks, specifies varying access size from byte to quadword, varying the offset from a page boundary from 8 bytes before through 1 byte after the page boundary, and varying address space from P0 to system.
2. **Create defaults** -- Defaults are provided for any variables not specified in the SCC.
3. **Execute subsection** -- A procedure is called that will make test references, varying each reference variable specified in the SCC across the range.

Clean up -- At the end of the test, all buffers are returned and control returns to the dispatch routine in the supervisor.

6.5.1.2 Memory Management Test, Subsection Flow

Loop start -- All reference parameters that will vary are loaded with initial values specified in the SCC.

Execute -- The test reference described by the current state of all the reference variables is made.

Increment -- The next value of the most rapidly varying parameter is loaded. If its range has been covered, it is set to its initial value and the next variable is changed.

Loop -- If the slowest varying reference parameter has completed its range, the subsection is complete. Otherwise, the next reference is made.

6.5.1.3 Test Reference Execution

Initialize -- The control blocks for this section (MRDB and TCB) are set up.

Decode -- A CITS (CITS_DECODE) is called to decode the test instruction.

Simulate -- The test reference is simulated, and the expected results are loaded into the MRDB.

Setup -- Another CITS routine (CITS_SETUP) is called to initialize the data areas, general register, and stack for the test instruction.

Map -- The address of the test reference is mapped according to the variables controlling page validity and accessibility.

Probe -- A probe is made to the test address in order to verify the mapping, and the results are compared with the simulated results.

Execute -- The test reference is made.

Remap -- The test address mapping is reset to allow all access, and the result maps are copied and checked.

Data Check -- CITS_CHECK is called to check the results of the test instruction.

Loop -- The flow from setup is repeated for various translation buffer states.

Return.

Typical Error Messages

```

***** CPU CLUSTER EXERCISER -- 9.0 *****

PASS 1 TEST 1 SUBTEST 1 ERROR 20212 28-MAY-1978 08:31:01.89

HARD ERROR WHILE TESTING CPU: LENGTH REGISTER BOUNDARY

ERROR OCCURRED DURING: ACCESS OR ACCESS CHECK

ERROR: PAGE TABLE ENTRY WAS MODIFIED

TESTED      PSL      MODE      ACCESS      ACCESS
ADDRESS      PRV      CUR      TYPE      SIZE
80001FF8     K       K       R          L

          PTE          PTE          PROTEC-  V-BIT  M-BIT  ACCESS  ALLOWED
          ADDRESS      VALUE          TION      STATE  STATE  K   E   S   U
SPTE1:  0001F43C  000000098  0003      VAL    CLR    R  NO  NO NO
SYS BASE      SYS LENGTH
REG  REG
0001F400      00000022

EXP DATA      ACT DATA      PTE MODIFIED
00000098      00000098      SPTE1:

```

Example 6-57 ESKAZ Test 1, Subtest 1, Error 20212

```

***** CPU CLUSTER EXERCISER -- 9.0 *****
PASS 1 TEST 1 SUBTEST 1 ERROR 20213 28-MAY-1978 08:50:58.91
HARD ERROR WHILE TESTING CPU: LENGTH REGISTER BOUNDARY
ERROR OCCURRED DURING: ACCESS OR ACCESS CHECK
ERROR: MODIFY BIT ERROR

TESTED      PSL  MODE  ACCESS  ACCESS  TESTED  OPERAND
ADDRESS      PRV  CUR   TYPE    SIZE    INSTR  NO.
6013001F8   K    K     W      L      MOV    02

          PTE      PTE      PROTEC-  V-BIT  M-BIT  ACCESS  ALLOWED
                        TION
          ADDRESS  VALUE    CODE     STATE  STATE  K  E  S  U
SPTE1:  0001F480  00000094  0002     VAL   SET   RW NO  NO NO

T-BUFF
STATE
MISS

PPTE1:  0001F200  00000094  0002     VAL   SET   RW NO  NO NO

HIT

SYS BASE    SYS LENGTH
REG          REG
0001F400    00000022
P1 BASE     P1 LENGTH
REG          REG
7FC01A00    0010000F
EXPECTED    PTE
STATE
SET          SPTE1:

```

Example 6-58 ESKAZ Test 1, Subtest 1, Error 20213

Interpretation of Example 6-57

1. First, a discussion of ERROR 20212

All error numbers consist of 3 bytes with a breakdown as follows:

- a. The left byte (2) defines the location within the test where the error was encountered

where,

0 = Subtest

1--6 = Subsection defined prior to the preceding examples (Paragraph 6.5.1).

- b. The middle byte (02) indicates the action being taken by the test at the time of error

where,

0 = SETUP

1 = PROBE/PROBE CHECK

2 = ACCESS/ACCESS CHECK

3 = ACCESS DATA CHECK

4 = FINAL SETUP

- c. The right byte (12) is indicative of the error itself (it is used by the test software to determine what gets printed at error report time).

So, the ERROR number tells us that we were in the LENGTH REGISTER BOUNDARY subsection (2) performing an ACCESS/ACCESS CHECK (02), when we got a message saying PAGE TABLE ENTRY WAS MODIFIED (12).

2. The ADDRESS UNDER TEST was 80001FF8.

3. The PREVIOUS and CURRENT MODES in the PSL at the test time are shown as K K

where,

K = Kernel

E = Executive

S = Supervisor

U = User

4. The ACCESS occurring at the time of the error is shown as R

where,

R = Read
W = Write
M = Modify

5. The SIZE of the access is shown as L

where,

L = Longword
B = Byte
W = Word
Q = Quadword

6. A discussion of the line labeled SPTE1 follows.

In the given example we have only one line of information, but depending on the set of circumstances there can be more than one line (as shown in Example 6-58).

The lines and combinations that can appear are as follows:

SPTE1: Page 1 system page table
SPTE2: Page 2 system page table
PPTE1: Page 1 processor page table
PPTE2: Page 2 processor page table

where,

Page 1 = page number of the address of the lowest byte of the reference address as determined by either the Base Virtual Address (BVA) or, if the position is negative, by the BVA + position.

Page 2 = the next page.

NOTE

A reference may be either entirely within PAGE 1 or PAGE 2, or it may cross over.

In our example, the PAGE 1 system page table is being ACCESSED.

7. The PHYSICAL ADDRESS of the PTE is 1F43C.

NOTE

The PTE is the medium of translation of all virtual addresses to physical addresses.

8. The PTE VALUE represents the contents of the PTE or 98.

The PTE content comprises 4 fields.

- a. Page Frame Number (PFN) -- Bits <20:00>

This is the upper 21 bits of the physical address of the base of the page.

- b. Modify bit -- Bit <26>

- c. Protection -- Bits <30:27>

- d. Valid -- Bit <31>

9. The PROTECTION CODE for the page accessed was 3.

10. Chapter 5 of the VAX-11 System Reference Manual gives an analysis of a protection code meaning.

To ease the strain of searching through the VAX-11 System Reference Manual, the protection code breakdown is shown under ACCESS ALLOWED as R, NO, NO, NO.

This states that the page being accessed can be READ in kernel mode, and cannot be accessed in any other mode.

NOTE

A W under this column would indicate that the page can be written in a given mode.

11. The state of the valid bit (V-BIT) is VAL

where,

VAX = 1 (valid)

INV = 0 (invalid)

12. The state of the modify bit (M-BIT) is CLR

where,

CLR = 0 (no modify)

SET = 1 (modify)

13. The content of the SYSTEM BASE REGISTER was 1F400 and the content of the SYSTEM LENGTH REGISTER was 22.

These 13 items represent the SETUP portion of the error report (i.e., what were all the initial conditions, or states, at the time of the error).

The SYS BASE REG and SYS LGTH REG printouts always occur as parts of the SETUP. As a function of the TESTED ADDRESS value, one or two other printouts will occur additionally as follows:

- a. If bit 31 is clear and bit 30 is set, the message includes

P1 BASE P1 LENGTH
REG REG

- b. If bit 31 is clear and bit 30 is clear, the message includes

P0 BASE P0 LENGTH
REG REG

14. The ERROR portion of the printout shows further proof of the ERROR: PAGE TABLE ENTRY WAS MODIFIED statement by showing the EXPECTED and ACTUAL DATA and the PTE MODIFIED.

Example 6-58 is similar to Example 6-57 except that it shows additional information which reflects circumstances at the time of the error.

The new items in Example 6-58 are:

- a. TESTED INSTR is a MOV
b. The OPERAND NO. in question is 02 (i.e., the DST).
c. The translation buffer state (TB-STATE) is listed

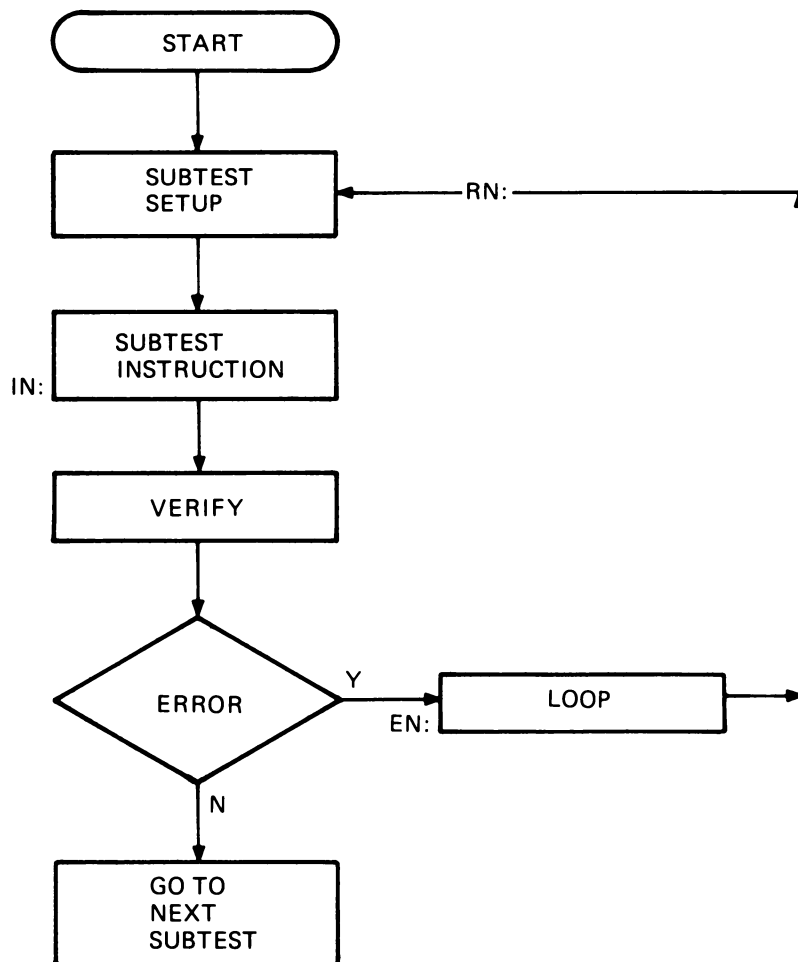
where,

HIT = 1
MISS = 0.

6.6 COMPATIBILITY MODE INSTRUCTION TEST (ESKAZ03, TEST 2)

6.6.1 Instructions Tested

Most of the instructions provided by the compatibility mode hardware are exercised using various data patterns and address modes (Figure 6-3). These instructions are listed in Table 6-12.



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Figure 6-3 Compatibility Mode Instruction Module Subtest Structure

Table 6-12 Compatibility Mode Instructions Provided by Compatibility Mode Hardware and Exercised by ESKAZ Test 2

Op Code (8)	Mnemonic	Op Code (8)	Mnemonic
.055DD	ADC (B)	0001DD	JMP
.06SSDD	ADD	004RDD	JSR
.063DD	ASL (B)	.1SSDD	MOV (B)
.062DD	ASR (B)	.054DD	NEG (B)
.4SSDD	BIC (B)	.061DD	ROL (B)
.5SSDD	BIS (B)	.060DD	ROR (B)
.3SSDD	BIT (B)	.0020R	RTS
400-3777	BRANCHES (*)	000006	RTT
100000-3777	BRANCHES (**)	.056DD	SBC (B)
.050DD	CLR (B)	077RNN	SOB
.2SSDD	CMP (B)	16SSDD	SUB
.051DD	COM (B)	0003DD	SWAB
240-277	CND CODES (***)	0067DD	SXT
.053DD	DEC (B)	.057DD	TST (B)
.052DD	INC (B)	074RSS	XOR

where,

(*)=BR, BNE, BEQ, BGE, BLT, BGT, BLE

(**)=BPL, BMI, BVC, BCC, BCS, BHI, BLOS, BHIS, BLO

(***)=CLC, CLV, CLZ, CLN, CCC, SEC, SEV, SEZ, SEN, SCC

The instructions provided by the compatibility mode hardware that have not yet been included in this test are listed in Table 6-13.

Table 6-13 Compatibility Mode Instructions Not Yet Tested

Op Code (8)	Mnemonic
072RSS	ASH
073RSS	ASHC
071RSS	DIV
1065SS	MFPD
0065SS	MFPI
1066DD	MTPD
0066DD	MTPI
070RSS	MUL

NOTES

1. The test instruction is always tagged IN.
2. The error is always tagged EN.
3. The return point for looping is always tagged RN.
4. If more than one verification is made in a single subtest, the entries to subsequent checks are tagged AN, BN, etc.
5. If more than one error is included, subsequent errors are tagged E1N, E2N, E3N, etc.

The RTI instruction provided by compatibility mode hardware is not tested in this module. The compatibility mode entry/exit module (ESKAX02, Test 01) tests this instruction thoroughly.

6.6.2 Compatibility Mode Test Error Message Format

The following header is printed when an error is detected.

(PC) (PSW) (SP) (R1) (R2) (R3) (R4)

Interpretation of Compatibility Mode Test Error Message Format

- (PC) Indicates the content of the program counter at the time of the error call. This is normally an address that is used to locate the error call statement in the failing subtest.
- (PSW) Indicates the content of the processor status word at the time of the error call.
- (SP) Indicates the content of the stack pointer (R6) at the time of the error.

NOTE

The error call will push the stack twice.

- (R1) Indicates a mnemonic of the instruction under test
e.g., MOVB, ASL . . . et al.
- (R2) For single- and double-operand instructions, R2 normally contains the destination address.
- (R3) For single- and double-operand instructions, R3 contains what the result (destination operand) actually was after the test instruction was executed.
- (R4) For single- and double-operand instructions, R4 contains what the result (destination operand) should have been (S/B).

In some cases, the error information may deviate from that previously described but the program annotation for those subtests will describe the meaning of those entries that have been redefined.

The error call statement is encoded to print only the information relative to the particular function being tested. Interpretation of the error calls is shown below.

```

ERROR      Print all 7 columns
ERROR1     Print only column 1
ERROR2     Print columns 1, 2
ERROR3     Print columns 1, 2, 3
ERROR4     Print columns 1, 2, 3, 4
ERROR5     Print columns 1, 2, 3, 4, 5
ERROR6     Print columns 1, 2, 3, 4, 5, 6

```

6.6.3 Sample Error Message Explanation

```

***** CPU CLUSTER . . . . . *****
PASS 1 TEST XX SUBTEST 208 . . . . .
HARD ERROR WHILE TESTING CPU: COMPATIBILITY MODE . . . . .
(PC)      (PSW)      (SP)      (R1)  (R2)      (R3)      (R4)
00008DD0  00000004  0000A5AA  MOV   00000400  00000000  0000FFFF

```

Example 6-59 ESKAZ Compatibility Mode Test Error

Interpretation of Example 6-59

8DD0	Represents the PC of the error call in the listing.
4	Represents the content of the PSW prior to the error call.
A5AA	Represents the last position of the PDP-11 mode stack pointer (R6).
MOV	Is a clue that the MOV instruction failed under test.
400	Represents the address used by the destination mode portion of the MOV instruction.
0000	Represents the actual content of the destination after instruction execution.
FFFF	Represents what the content of the destination should have been after the MOV instruction was executed.

The listing is laid out with a subtitle printed at the top of each page. The operator can look through the program listing for subtest 208. The subtest description of 208 shows that a MOV instruction is tested with source mode 2 and destination mode 3.

6.6.4 Compatibility Mode Instruction Module Assumptions

Four compatibility mode trap instructions are used to control the execution of this test, as follows.

1. SUBTYPE 0 (SPL) Used as program end indicator.
2. SUBTYPE 2 (IOT) Used as next subtest indicator.

NOTE

Appears as SCOPE statement in listing.

3. SUBTYPE 3 (EMT) Used as error report indicator.

NOTE

Appears as ERROR + XX statement in listing.

4. SUBTYPE 4 (TRAP) Used as PSW reference indicator.

NOTE

Appears as TRAP + XX statement in listing.

It is assumed that the test performing the exercising of compatibility mode entry/exit conditions has been executed prior to this test, in which event, the compatibility mode trap instructions have been checked out.

APPENDIX A GLOSSARY OF DIAGNOSTICS SOFTWARE TERMS

absolute (ABS) -- A program section (psect) attribute. An absolute psect contains only symbol definitions. It does not contribute binary code to the image. Therefore, it must have a zero-length memory allocation. The converse is relocatable (REL).

access mode -- Any of the four processor access modes in which software executes. Processor access modes are, in order, from most to least privileged and protected: kernel (mode 0), executive (mode 1), supervisor (mode 2), and user (mode 3).

When the processor is in kernel mode, the executing software has complete control of, and responsibility for, the system. When the processor is in any other mode, the processor is inhibited from executing privileged instructions. The processor status longword contains the current access mode field. The operating system uses access modes to define protection levels for software executing in the context of a process. For example, the executive runs in kernel and executive modes and is most protected. The command interpreter is less protected and runs in supervisor mode. The debugger runs in user mode and is no more protected than normal user programs.

access type -- The way in which the processor accesses instruction operands. Access types are: read, write, modify, address, and branch.

alignment -- The address boundary at which a program section is based.

allocate a device -- To reserve a particular device unit for exclusive use. A user process can allocate a device only when that device is not allocated by any other process.

allocation -- The number of bytes of memory contributed by a program section to a particular module.

alphanumeric character -- An upper or lower case letter (A--Z, a--z), a dollar sign (\$), an underscore (_), or a decimal digit (0--9).

ancillary control process (ACP) -- A process that acts as an interface between user software and an I/O driver. An ACP provides functions supplemental to those performed in the driver, such as file and directory management.

argument -- An independent value within a command statement that specifies where, or on what, the command will operate (e.g., address, data).

argument pointer -- General register 12 (R12). By convention, AP contains the address of the base of the argument list for procedures initiated using the CALL instructions.

assign a channel -- To establish the necessary software linkage between a user process and a device unit before a user process can transfer any data to or from that device. A user process requests the system to assign a channel and the system returns a channel number.

assembler -- A program that translates source language code, whose operations correspond directly to machine op codes, into object language code.

asynchronous system trap (AST) -- A software-simulated interrupt to a user-defined service routine. ASTs enable a user process to be notified asynchronously, with respect to its execution, of the occurrence of a specific event. If a user process has defined an AST routine for an event, the system interrupts the process and executes the AST routine when that event occurs. When the AST routine exits, the system resumes the process at the point where it was interrupted.

attributes -- Various characteristics that can be assigned by the programmer to each psect in a module (e.g., ABS).

base register -- A general register used to contain the address of the entry in a list, table, array, or other data structure.

block -- 1. The smallest addressable unit of data that the specified device can transfer in an I/O operation (512 contiguous bytes for most disk devices). 2. An arbitrary number of contiguous bytes used to store logically related status, control, or other processing information (i.e., process control block).

breakpoint -- In diagnostics, an address assigned through the diagnostic supervisor. When the PC equals the value of the breakpoint, control returns to the diagnostic supervisor.

boot (bootstrap) -- A program that loads another (usually larger) program into memory from a peripheral device.

buffer -- A temporary data storage area.

call frame -- A standard data structure built on the stack during a procedure call, starting from the location addressed by the FP to lower addresses, and popped off during a return from procedure (also called stack frame).

channel -- A logical path connecting a user process to a physical device unit. A user process requests the operating system to assign a channel to a device so that the process can transfer data to or from that device.

command file -- A file containing command strings.

command interpreter -- Procedure-based code to receive, syntax check, and parse commands typed by the user at a terminal or submitted in a command file.

command parameter -- The positional operand of a command delimited by spaces, such as a file specification, option, or constant.

command string -- A line, or a set of continued lines, normally terminated by typing the carriage return key containing a command, and optionally, information modifying the command. A complete command string consists of a command; its qualifiers, if any; its parameter (file specifications, for example), if any; and their qualifiers, if any.

concatenate (CON) -- A program section attribute. If a psect is concatenated, all psects of the same name yet from different modules are to be assigned contiguous addresses in the virtual address space. Each module can specify an independent alignment. The linker performs the necessary padding of zero bytes between contributions. The base alignment of the resulting concatenated psects is according to the greatest alignment granularity of all the contributions to the psect. For example, if the greatest alignment granularity of all contributors is a page, the psect is page-aligned; although, some contributors may be byte-aligned, others word-aligned, etc.

condition -- An exception condition detected and declared by software.

condition codes -- Four bits in the processor status word that indicate the results of the previously executed instruction.

condition handler -- A procedure that a process wants the system to execute when an exception condition occurs. When an exception condition does occur, the operating system searches for a condition handler. When it finds the condition handler, the operating system initiates the handler immediately. The condition handler may perform some act to change the situation that caused the exception condition and then continue execution of the process that incurred the exception condition. Condition handlers execute in the context of the process at the access mode of the code that incurred the exception condition.

context switching -- Interrupting the activity in progress and switching to another activity. Context switching occurs as one process after another is scheduled for execution. The operating system saves the interrupted process's hardware context in its hardware PCB using the save process context instruction, loads another process's hardware PCB into the hardware context using the load process context instruction, and schedules that process for execution.

cylinder -- The tracks at the same radius on all recording surfaces of a disk pack.

default -- Assumed value supplied when a command qualifier does not specifically override the normal command function; also, fields in a file specification that the system fills in when the specification is not complete.

default disk -- The system disk to which the system writes all files that the operator creates, by default. The default is used whenever a file specification in a command does not explicitly name a device.

delimiter -- A character or symbol used to separate or limit items within a command or data string. However, the delimiter is not a member of the string.

device -- The general name for any physical terminus or link connected to the processor that is capable of receiving, storing, or transmitting data. Card readers, line printers, and terminals are examples of record-oriented devices. Magnetic tape devices and disk devices are examples of mass storage devices. Terminal line interfaces and interprocessor links are examples of communications devices.

device interrupt -- An interrupt received on interrupt priority levels 16 through 23. Device interrupts can be requested only by devices, controllers, and memories.

device name -- The field in a file specification that identifies the device unit on which a file is stored. Device names also include the mnemonics that identify an I/O peripheral device in a data transfer request. A device name consists of a mnemonic followed by a controller identification letter (if applicable), followed by a unit number (if applicable). A colon (:) separates it from following fields.

direct I/O -- A mode of access to peripheral devices in which the program addresses the device registers directly, without relying on support from the operating system drivers.

drive -- The electro-mechanical unit of a mass storage device system on which a recording medium (disk cartridge, disk pack, or magnetic tape reel) is mounted.

driver -- The set of system code that handles physical I/O to a device.

entry mask -- A word (1) whose bits represent the registers to be saved or restored on a subroutine or procedure call using the call and return instructions, and (2) which includes trap enable bits.

entry point -- A location that can be specified as the object of a call. It contains an entry mask and exception enables known as the entry point mask.

event -- A change in process status or an indication of the occurrence of some activity that concerns an individual process or cooperating processes. An incident reported to the scheduler that affects a process's ability to execute. Events can be synchronous with the process's execution (a wait request, or they can be asynchronous (I/O completion). Some examples of events: swapping, wake request, page fault.

event flag -- A bit in an event flag cluster that can be set or cleared to indicate the occurrence of the event associated with that flag. Event flags are used to synchronize activities in a process or among many processes.

exception -- An event detected by the hardware (other than an interrupt or jump, branch, case, or call instruction) that changes the normal flow of instruction execution. An exception is always caused by the execution of an instruction or set of instructions, while an interrupt is caused by an activity in the system independent of the current instruction. There are three types of hardware exceptions: traps, faults, and aborts. Examples are: attempts to execute a privileged or reserved instruction; trace traps; compatibility mode faults; breakpoint instruction execution; and arithmetic traps such as overflow, underflow, and divide-by-zero.

exception condition -- A hardware- or software-detected event (other than an interrupt or jump, branch, case, or call instruction) that changes the normal flow of instruction execution.

exception dispatcher -- An operating system procedure that searches for a condition handler when an exception condition occurs. If no exception handler is found for an exception or condition, the image that incurred the exception is terminated.

executable (EXE) -- A program section attribute. The psect contains only instructions. This attribute provides the capability to separate instructions from read-only and read/write data. The linker uses this attribute in gathering psects and in the verification of the transfer address that must be present in an executable psect.

executable image -- An image that is capable of being run in a process. When run, an executable image is read from a file for execution in a process.

executive -- The generic name for the collection of procedures included in the operating system software that provides the basic control and monitor functions of the operating system.

file -- A logically related collection of data treated as a physical entity that occupies one or more blocks on a volume such as disk or magnetic tape. A file can be referenced by a name assigned by the user. A file normally consists of one or more logical records.

file specification -- A unique name for a file on a mass storage medium.

frame pointer -- General register 13 (R13). By convention, FP contains the base address of the most recent call frame on the stack.

global symbol -- A symbol defined in a module that is potentially available for reference by another module. The linker resolves (matches references with definitions) global symbols. Contrast with local symbol.

granularity -- The alignment of a contribution to a psect on a boundary. The alignment granularity may be byte, word, quadword, or page.

home block -- A block in the index file that contains the volume identification, such as volume label and protection.

image -- An image consists of procedures and data that have been bound together by the linker. There are three types of images: executable, sharable, and system.

index file -- The file on a FILES-11 volume that contains the access information for all files on the volume and enables the operating system to identify and access the volume.

interrupt -- An event (other than an exception or branch, jump, case, or call instruction) that changes the normal flow of instruction execution. Interrupts are generally external to the process executing when the interrupt occurs.

interrupt stack -- The system-wide stack used when executing in an interrupt service context. At any time, the processor is either in a process context executing in user, supervisor, executive, or kernel mode; or in system-wide interrupt service context operating with kernel privileges, as indicated by the interrupt stack and current mode bits in the PSL. The interrupt stack is not context-switched.

I/O function code -- A 6-bit value specified in a queue I/O request system service that describes the particular I/O operation to be performed (e.g., read, write, rewind).

library file -- A direct access file containing one or more modules of the same module type.

linked commands -- A group of independent commands connected together (linked) so as to form a single executable list of commands. Once initiated, the entire linked command list may be executed without further operator intervention.

linker -- A program that reads one or more object modules created by language processors and produces an executable image file, a sharable image file, or a system image file.

linking -- The resolution of external references between object modules used to create an image; the acquisition of referenced library routines, service entry points, and data for the image; and the assignment of virtual addresses to components of an image.

link map -- A link map shows the virtual memory allocation of the total program image. The link map is found in a program listing in the program section allocation synopsis.

literal -- An operand which is used immediately, without being translated to some other value. An operand which specifies itself.

literal argument -- An independent value within a command statement that specifies itself.

local symbol -- A symbol that is meaningful only to the module that defines it. Symbols not identified to a language processor as global symbols are considered to be local symbols. A language processor resolves (matches references with definitions) local symbols. They are known to the linker and cannot be made available to another object module. They can, however, be passed through the linker to the symbolic debugger. Contrast with global symbol.

logical block -- A block on a mass storage device identified by using the volume-relative address rather than the physical (device-oriented) address or the virtual (file-relative) address. The blocks that comprise the volume are labeled sequentially starting with logical block 0.

macro -- A statement that requests a language processor to generate a predefined set of instructions.

memory management -- The system functions that include the hardware's page mapping and protection and the operating system's image activator and pager.

module -- A part of a program assembled as a unit. Modular programming allows the development of large programs in which separate parts share data and routines.

mount a volume -- To logically associate a volume with the physical unit on which it is loaded (an activity accomplished by system software at the request of an operator). Or, to load or place a magnetic tape or disk pack on a drive and place the drive on-line (an activity accomplished by a system operator).

object module -- The binary output of a language processor such as the assembler or a compiler, which is used as input to the linker.

operand -- a value (address or data) that is operated on, or with, by an instruction.

overlay (OVR) -- A program section attribute. If a psect is overlaid, all contributions to the psect have the same base address. The length of the psect is the size of the largest contribution. All contributions to an overlaid psect must have the same alignment.

page -- A set of 512 contiguous byte locations used as the unit of memory mapping and protection. Also, the data between the beginning of a file and a page marker, between two markers, or between a marker and the end of a file.

page frame number (PFN) -- The address of the first byte of a page in physical memory. The high-order 21 bits of the physical address of the base of a page make up the PFN.

page table entry (PTE) -- The data structure that identifies the location and status of a page of virtual address space. When a virtual page is in memory, the PTE contains the page frame number needed to map the virtual page to a physical page. When it is not in memory, the PTE contains the information needed to locate the page on secondary storage (disk).

parameter -- A parameter is the object of a command. It can be a file specification, a keyword option, or a symbol value passed to a command procedure. In diagnostics, parameters are usually operator-supplied answers to questions asked by a program concerning devices to be tested.

parameter switch -- A command qualifier. In diagnostics, it is preceded by a slash (/).

parser -- A procedure that breaks down the components of a command into structural forms.

physical address -- The address used by hardware to identify a location in physical memory or on directly addressable secondary storage devices such as disks. A physical memory address consists of a page frame number and the number of a byte within the page. A physical disk block address consists of a cylinder or track and sector number.

physical block -- A block on a mass storage device referred to by its physical (device-oriented) address rather than a logical (volume-relative) or virtual (file-relative) address.

position independent code (PIC) -- A program section attribute. The contents of the psect do not depend on a specific location in virtual memory. The converse is nonposition independent code (NOPIC).

priority -- The rank assigned to an activity that determines its level of service. For example, when several jobs contend for system resources, the job with the highest priority receives service first.

program section -- A portion of a module. The assembler creates a number of program sections (psect) within a module, according to directives by the program developer. In addition, any code that precedes the first defined program section is placed in the BLANK program section by the assembler.

Through program sectioning the program developer controls the virtual memory allocation of a program. Any program attributes established by the program section directive are passed on to the linker. Thus, program sections can be declared as read only, nonexecutable, etc. See the VAX-11 MACRO Language Reference Manual for an explanation of the various program section attribute functions.

In the diagnostic programs, each test is given a separate program section.

prompt -- A program's typed out response to and/or request for operator action.

qualifier -- A portion of a command string that modifies a command verb or command parameter by selecting one of several options. A qualifier, if present, follows the command verb or parameter to which it applies and is in the format: /qualifier:option. For example, in the command string "PRINT <filename> /COPIES:3", the COPIES qualifier indicates that the user wants three copies of a given file printed.

queue -- A list of commands or jobs waiting to be processed.

queue I/O -- A mode of access to peripheral devices in which a program calls on driver routines provided by the VMS operating system or the diagnostic supervisor to transfer data.

radix -- The base of the number system currently in use.

readable (RD) -- A program section attribute. The contents of the psect can be read at the execute time. The converse is nonreadable (NORD).

record -- A collection of adjacent items of data treated as a unit. A logical record can be of any length whose significance is determined by the programmer. A physical record is a device-dependent collection of contiguous bytes such as a block on a disk, or a collection of bytes sent to or received from a record-oriented device.

relocatable (REL) -- A program section attribute. The psect must be assigned a base address by the linker. This psect can contain code and/or data.

script file -- A line-oriented ASCII file that contains a list of commands.

section -- A group of tests in a diagnostic program that may be selected by the operator.

sector -- A portion of a track on the surface of a disk. On a VAX-11 system, each track on a disk is normally divided into 22 sectors.

semantics -- The interpretation of and relation between commands or command symbols.

sharable image -- An image that has all of its internal references resolved, but which must be linked with an object module(s) to produce an executable image. A sharable image cannot be executed. A sharable image file can be used to contain a library of routines. A sharable image can be installed as a global section by the system manager.

stack -- An area of memory set aside for temporary storage, or for procedure and interrupt service linkages. A stack uses the last-in, first-out concept. As items are added to (pushed on) the stack, the stack pointer decrements. As items are retrieved from (popped off) the stack, the stack pointer increments.

stack frame -- A standard data structure built on the stack during a procedure call, starting from the location addressed by the FP to lower addresses, and popped off during a return from procedure. Also called call frame.

stack pointer -- General register 14 (R14). SP contains the address of the top (lowest address) of the processor-defined stack. Reference to SP will access one of the five possible stack pointers: kernel, executive, supervisor, user, or interrupt, depending on the value in the current mode and interrupt stack bits in the Processor Status Longword (PSL).

standalone mode -- A diagnostic program environment in which the program and the diagnostic supervisor run without the VMS operating system. The operator must use the console terminal when running diagnostics in the standalone mode, and no other users have access to the system.

symbolic argument -- An argument within a command that refers to another value.

syntax -- The rules governing a command language structure. The way in which command symbols are ordered to form meaningful statements.

syntactic unit -- An item contained within a command statement (e.g., an argument, a qualifier).

system image -- The image that is read into memory from secondary storage when the system is started up.

test -- A unit of a diagnostic program that checks a specific function or portion of the hardware.

time stamp -- A statement of the time of day at which a specific event occurred.

track -- A collection of blocks at a single radius on one recording surface of a disk.

trap -- An exception condition that occurs at the end of the instruction that caused the exception. The PC saved on the stack is the address of the next instruction that would normally have been executed. All software can enable and disable some of the trap conditions with a single instruction.

unit record device -- A device such as a card reader or line printer.

unwind the call stack -- To remove call frames from the stack by tracing back through nested procedure calls using the current content of the FP register and FP register content stored on the stack for each call frame.

UUT (unit under test) -- The device or portion of the computer hardware being tested by a diagnostic program.

virtual block number -- A number used to identify a block on a mass storage device. The number is a file-relative address rather than a logical (volume-oriented) or physical (device-oriented) address. The first block in a file is always virtual block number one.

writable (WRT) -- A program section attribute. The content of the psect can be modified at execute time. The converse is nonwritable (NOWRT).

BLANK

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